

Section 4 Kālia Geographic Zone (T-198 to T-225)

4.1 Overall Location

For reporting purposes for this AIS, the City Center Section 4 of the HHCTCP has been divided into 11 zones based on geographical and cultural boundaries. The Kālia Geographic Zone runs along Kona Street. It extends east from Pi'ikoi Street to the HHCTCP terminus, *mauka* of the Ala Moana Shopping Center, just west of the Ala Moana Building (Figure 197). The Kālia Zone was located within the westernmost portion of Waikīkī Ahupua'a, in a physiographic division known as the Honolulu Plain (Armstrong 1983:36). Pi'ikoi Street serves as the approximate boundary between Waikīkī Ahupua'a and Honolulu Ahupua'a.

The Kālia Zone includes 28 test excavations numbered T-198 through T-225 (note that T-215, T-216, and T-223 through T-225 were abandoned). Test excavation numbering generally proceeds from northwest to southeast. All Kālia test excavations were conducted on private lands. T-198 through T-205, T-207, T-208, T-212, T-217, T-218, and T-220 through T-222 were located along a section of Kona Street owned by General Growth Properties (GGP), within TMK 2-3-038:001. T-219 was within TMK 2-3-039:004, owned by Izuo Brothers, Ltd. T-223 through T-225 were in the Ala Moana Center parking structure, also owned by GGP, within TMK 2-3-038:006. T-215 and T-216 were within TMK 2-3-039:006, owned P. H. Hawaii Corp. T-206 was within TMK 2-3-039:013, owned by Kaanapali Kai, Inc./Sanno USA, Inc. T-209 through T-211, T-213, and T-214 were within TMK 2-3-039:011, owned by Sam House Development, LLC. These five test excavations were originally part of a previous investigation (Burke and Hammatt 2012).

4.2 Geography, Geology, and Land Forms

The Kālia Zone was situated along the low-lying coastal flats immediately inland of present-day Ala Moana Beach Park and was just under 600 m from the modern shoreline. Present-day elevations in the zone range from approximately 1.4 to 2.4 m amsl, with an average elevation of approximately 1.6 m along the corridor. The Kālia Zone was on a portion of the broad elevated coral reef in southern O'ahu that probably formed during the 7.5 m (Waimanalo) stand (Macdonald et al. 1983:420-421).

Native vegetation in this area was not well documented, but just prior to development in the early twentieth century it included *naupaka* (*Scaevola taccada*), *keawe* (*Prosopis pallida*), and coconut (*Cocos nucifera*). Today, virtually all vegetation was a result of landscaping efforts that favor ornamental introduced trees, shrubs, and ground cover. The average annual rainfall ranges from 684 to 710 mm (26 to 28 in) (Giambelluca et al. 2011), which would be marginal at best for non-irrigated agriculture.

According to the U.S. Department of Agriculture Soil Survey Geographic (SSURGO) Database (2001) and soil survey data gathered by Foote et al. (1972), soils within the Kālia Zone consist entirely of Fill Land (FL) (Figure 197). Fill Land soils were described as:

...areas filled with material dredged from the ocean or hauled from nearby areas, garbage, and general material from other sources... This land type was used for

urban development including airports, housing areas, and industrial facilities [Foote et al. 1972:31].

4.3 Modern land Use and Built Environment

The Kālia Zone traverses a commercial urban environment, following along Kona Street. Parcels *mauka* of Kona Street contain various businesses and high-rise buildings. The Ala Moana Center parking complex lies *makai* of the corridor. The transit terminates just west of the Ala Moana Building. A massive utility corridor was present throughout the Kālia Zone containing electrical, gas, water, sewer, and storm lines. The number and distribution of these existing utilities indicate that this Kālia Zone portion of Kona Street has been heavily disturbed in the past.

4.4 GPR Sediment Summary

Test excavations in the Kālia Geographic Zone (Zone 10) revealed that the area was predominantly Fill Lands (FL) as predicted by the U.S.G.S Soil survey map of the zone (Figure 197). Naturally deposited sediments encountered in this zone were generally too deep for the GPR to clearly read. The average depth of clean signal return for this area was approximately one m. The only naturally deposited sediment observed in Zone 10 within the range of clean signal return was sandy clay located in T-207. Representative signal texture profiles for Zone 10 were shown in Figure 198. Signal texture profiles were only collected if the signal return was clear and the stratum was at least 0.25 m thick.

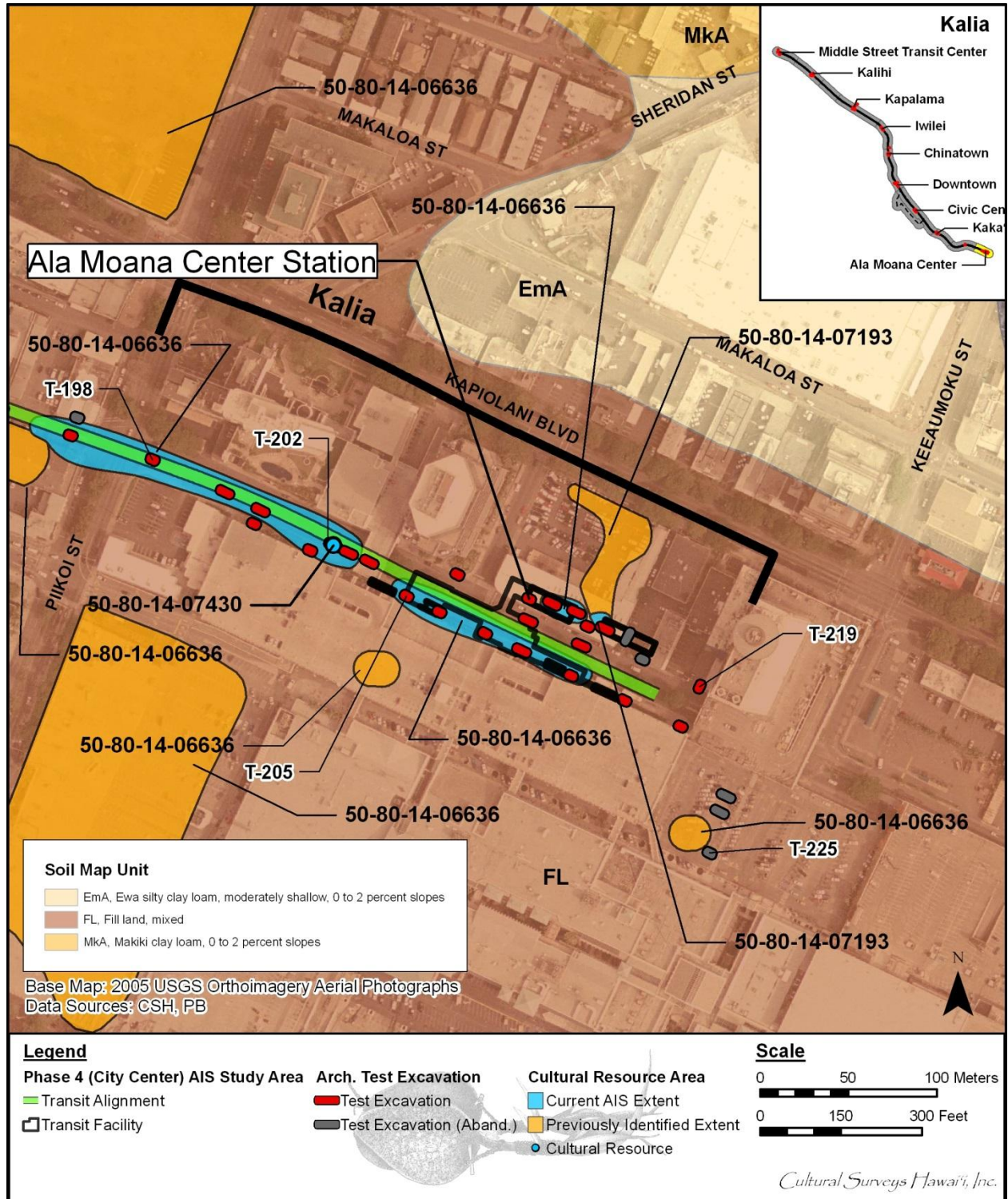
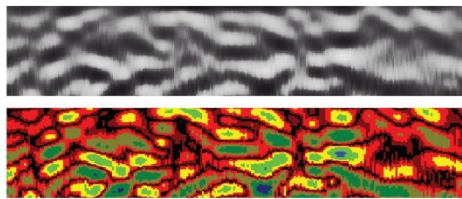
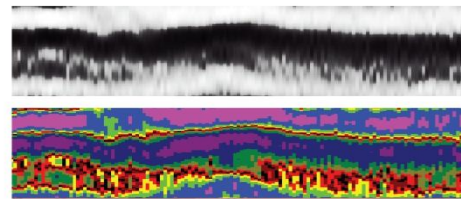


Figure 197. Aerial photograph (source: U.S. Geological Survey Orthoimagery 2005) with overlay of the Soil Survey of Hawai'i (Foote et al. 1972) showing sediment types within and in the vicinity of the Kalia Zone

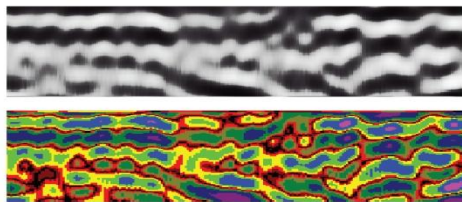
Examples of GPR Signal Textures Representing Zone 10 Sediments



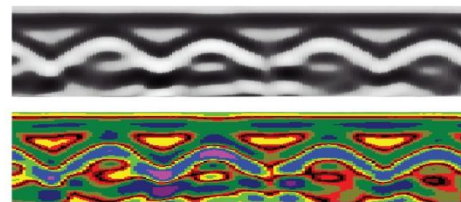
Extremely Gravelly Sand (T-199)



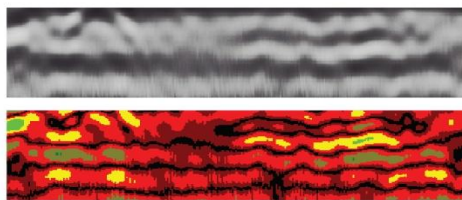
Silt Loam (T-209)



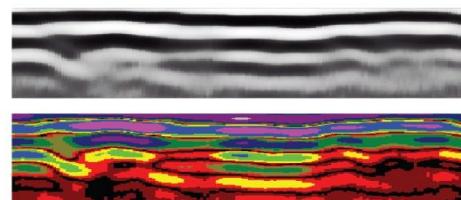
Cobbly Sand (T-201)



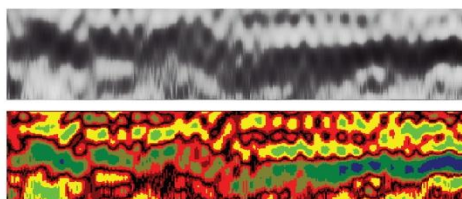
Reinforced Concrete (T-218)



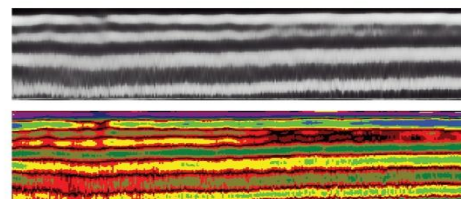
Extremely Gravelly Silty Sand (T-202)



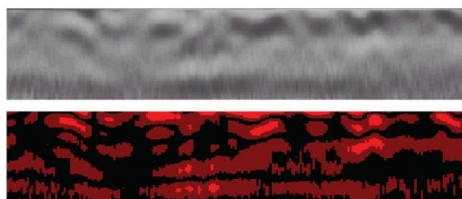
Silty Clay (T-219)



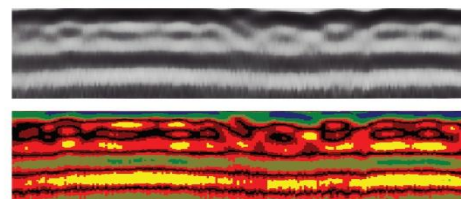
Very Gravelly Loamy Sand (T-202A)



Clay Loam (T-221)



Very Gravelly Silty Sand (T-203)



Extremely Bouldery Clay Loam (T-222)

Figure 198. Examples of GPR signal textures representing Zone 10 sediments

Test Excavation 198

T-198 measured 0.9 m by 3.0 m and was oriented northwest to southeast and was located within the median on Kona Street, 10.0 m east of Piikoi Street and Kona Street intersection. The GPR grid measured 3.0 m by 6.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water line 0.3 m northeast, electrical line 2.0 m west, water drain 3.2 m northeast. T-198 was slightly shortened to avoid the water utility box on the southeast end.

A review of amplitude slice maps indicated an anomaly that was a water utility box in the northeastern corner of the excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth except the water utility box. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs (Figure 199).

GPR depth profiles for T-198 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 200). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.1 mbs. No utilities observed in the profile. The maximum depth of clean signal return was approximately 1.0 mbs.

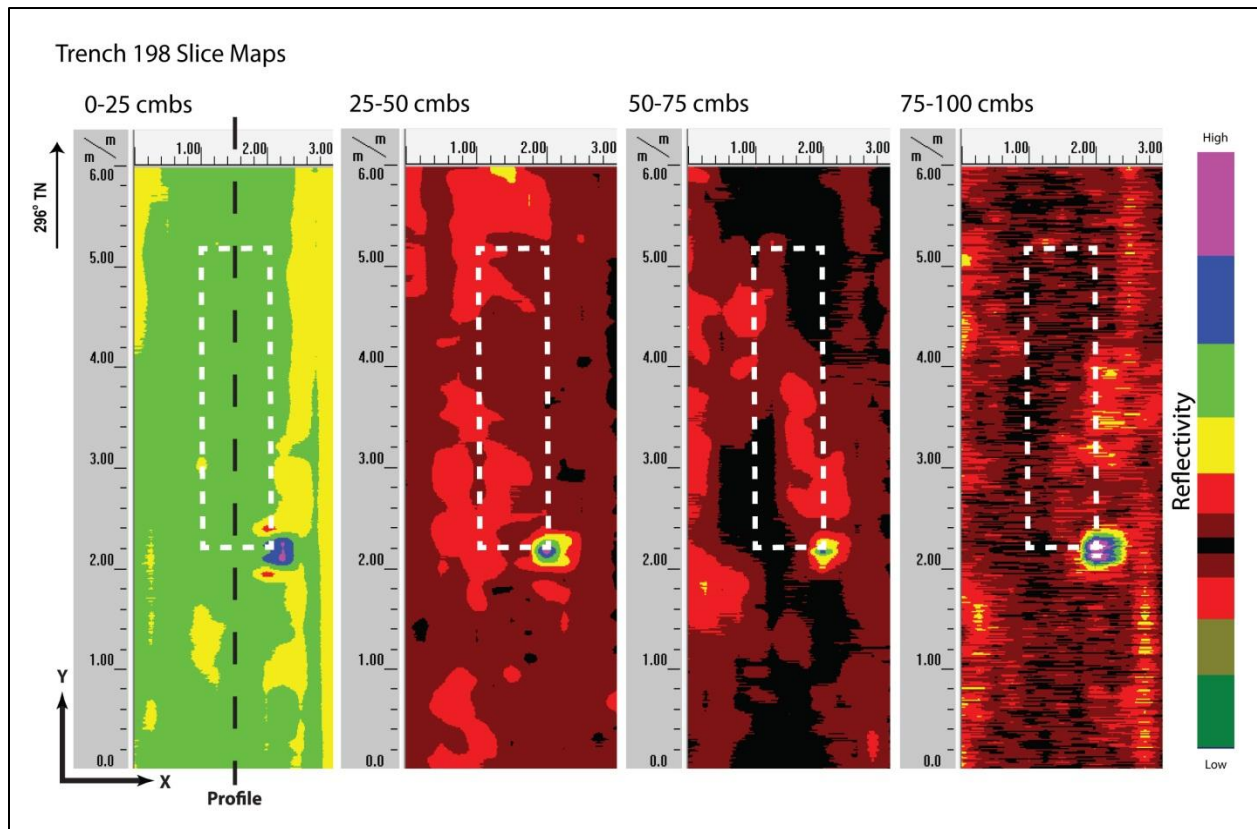


Figure 199. Slice maps of T-198 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 200). Strata Ia and Ic were clearly observed and occurred near the ground-truthed depths. Strata Ib to Id were comprised of very thin compacted layers that may be difficult to individually discern but also do not show the horizontal banding that was typical of this configuration. All other sediment transitions were below the maximum clean signal return depth. No discrete objects were observed in the GPR results or subsequent excavation.

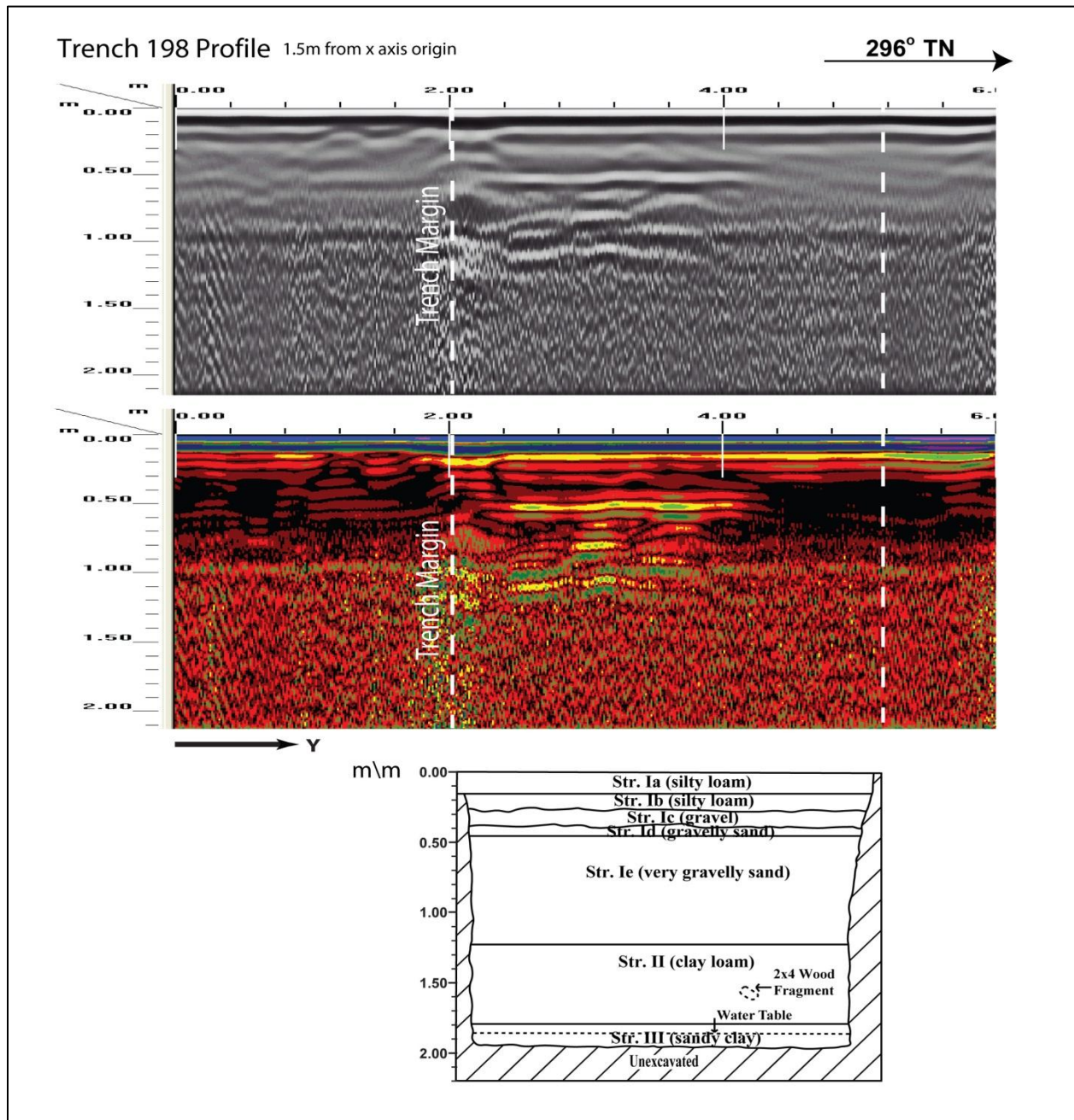


Figure 200. Visual comparison of excavated profile and GPR signal profile of T-198

Test Excavation 199

T-199 measured 0.9 m by 3.0 m and was oriented northwest to southeast and was located within the median on Kona Street, 51.0 m southeast of Piikoi Street and Kona Street intersection. The GPR grid measured 3.0 m by 6.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water line 1.5 m southwest, electrical line 2.5 m northeast. No utilities transected the excavation location.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.75 mbs (Figure 201).

GPR depth profiles for T-199 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 202). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.15 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 1.25 mbs.

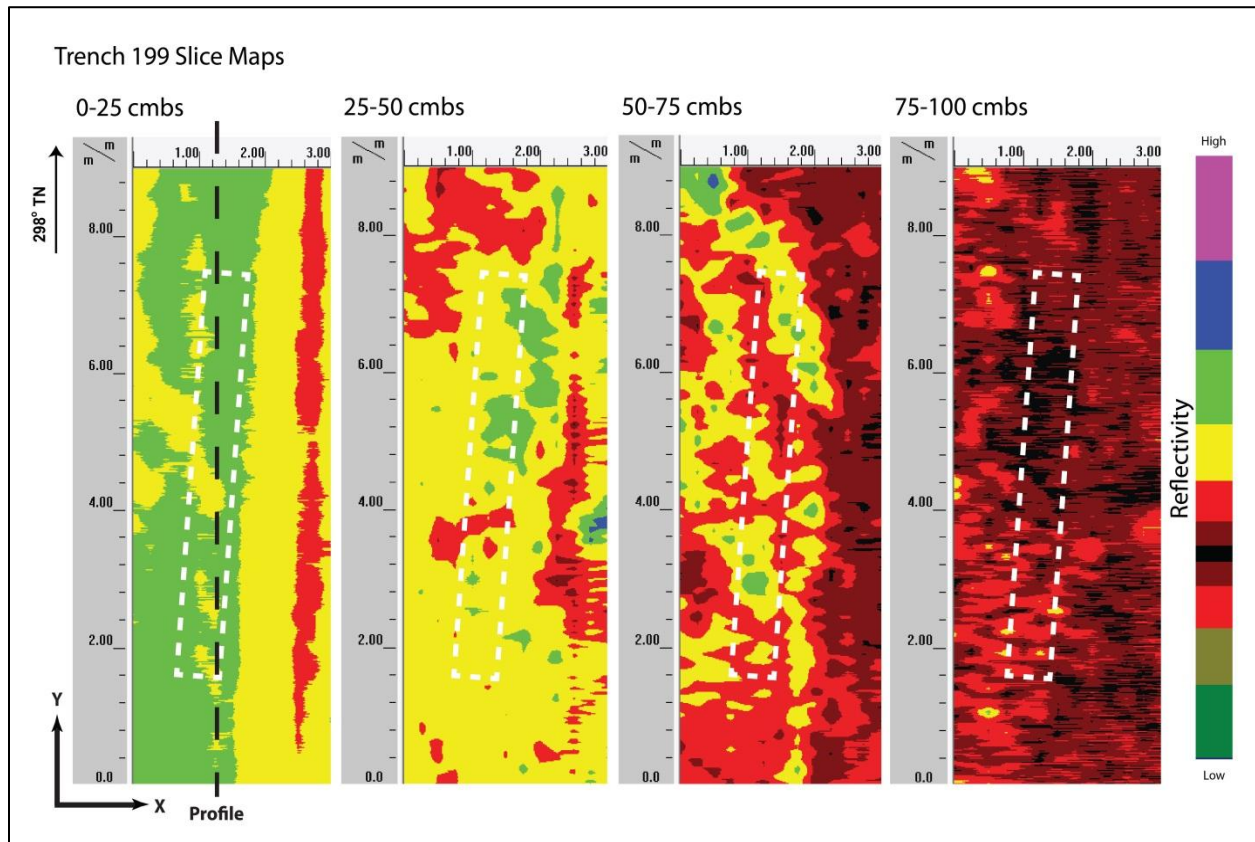


Figure 201. Slice maps of T-199 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 202). Strata Ia to Ie were clearly observed and occurred at the ground-truthed depths. Strata Ib and Id were difficult to discern because they were less than 0.05 m thick. All other sediment transitions were below the maximum clean signal return depth. No discrete objects were observed in the GPR results or subsequent excavation.

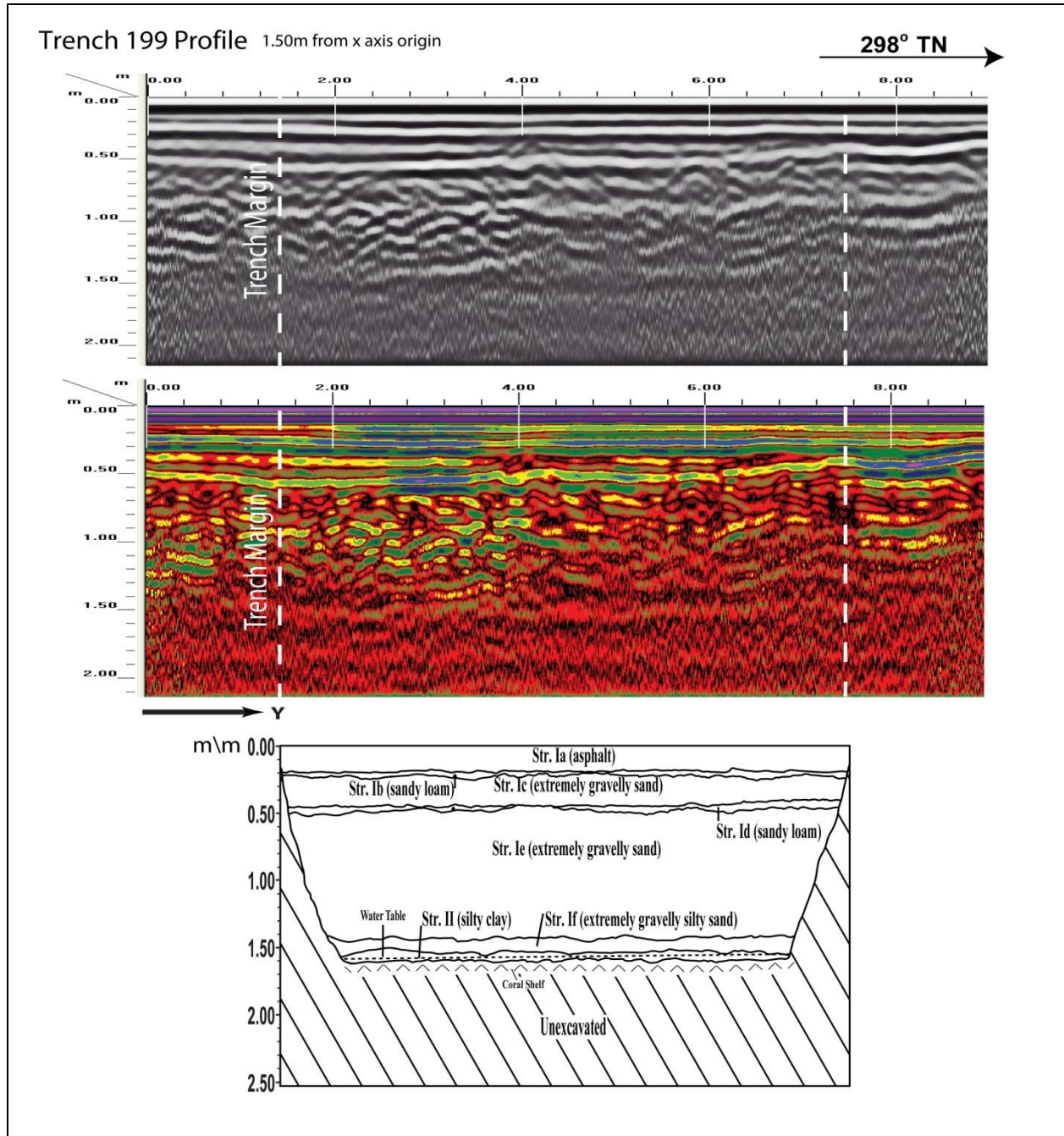


Figure 202. Visual comparison of excavated profile and GPR signal profile of T-199

Test Excavation 200

T-200 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Kona Street, 80.0 m southeast of Kona Street and Piikoi Street intersection. The GPR grid measured 3.0 m by 9.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water line 0.6 m northeast, water drain 2.8 m northeast, water line 6.0 m northeast.

A review of amplitude slice maps indicated a linear feature but was not encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 203).

GPR depth profiles for T-200 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 204). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.4 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 0.9 mbs.

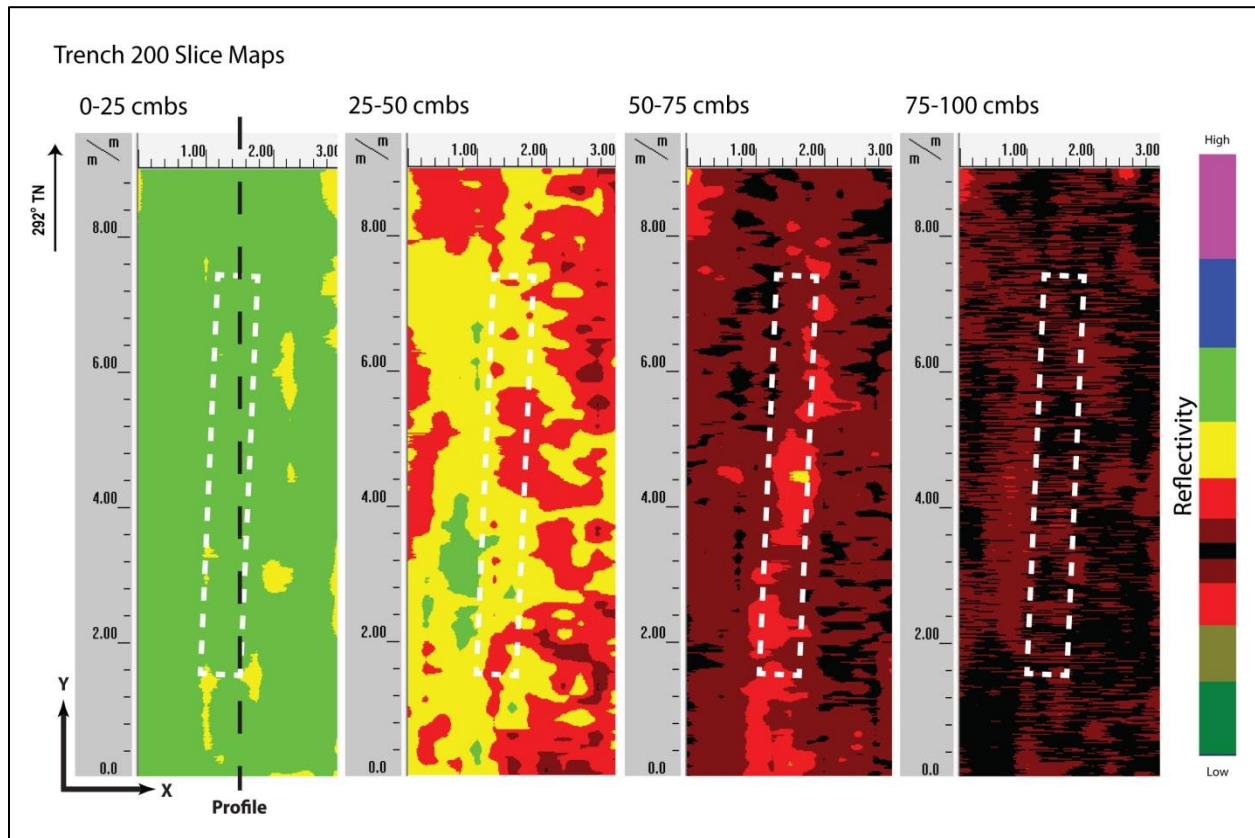


Figure 203. Slice maps of T-200 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 204). Strata Ia to If were clearly observed and occurred at the ground-truthed depths. Strata Ib through Ie were difficult to individually discern, possibly due to the fact that they were very thin layers of compacted fill, but based on reflectivity and horizontal banding it was apparent that there were multiple layers of fill events. All other sediment transitions were below the maximum clean signal return depth. No discrete objects were observed in the GPR results or subsequent excavation.

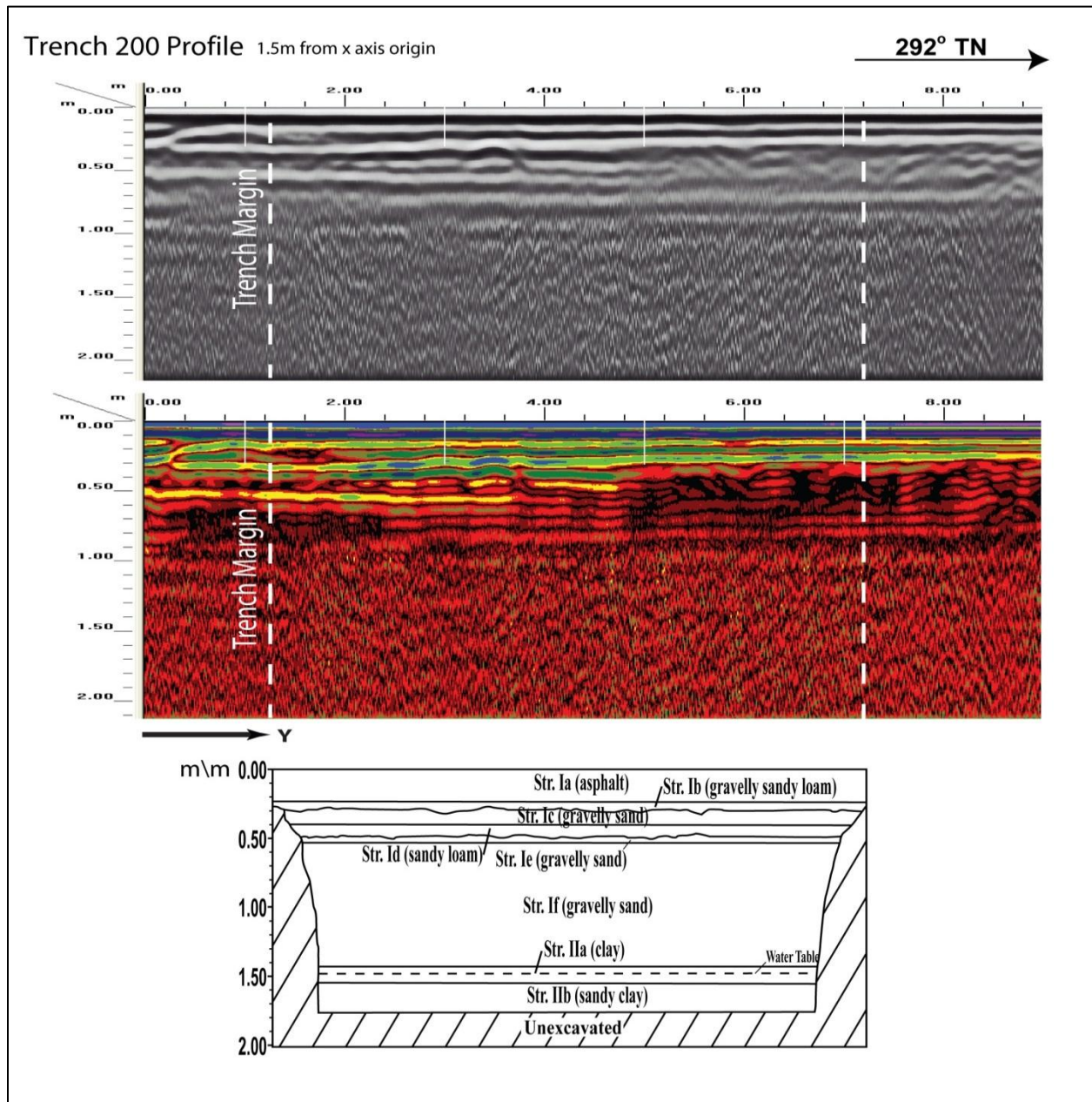


Figure 204. Visual comparison of excavated profile and GPR signal profile of T-200

Test Excavation 201

T-201 measured 1.0 m by 4.0 m and was oriented northwest to southeast and was located within the sidewalk on Kona Street, 80.0 m southeast of Kona Street and Piikoi Street. The GPR grid measured 2.0 m by 6.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water line 9.0 m northeast. No utilities transected the excavation location.

A review of amplitude slice maps indicated a linear feature but was not encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth except for the linear feature. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 205).

GPR depth profiles for T-201 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 206). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.35 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 1.0 mbs.

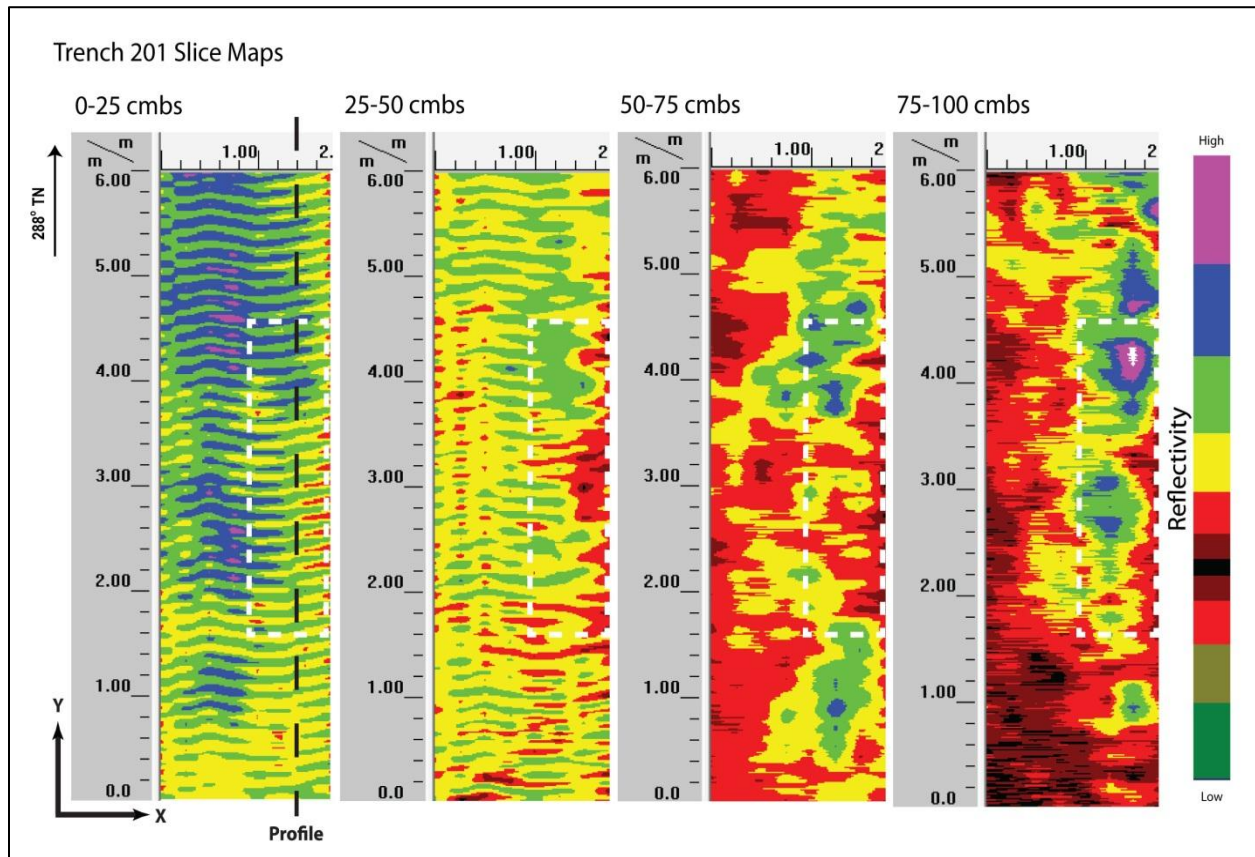


Figure 205. Slice maps of T-201 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a weak correlation in stratigraphic transitions (Figure 206). Strata included: concrete, sand fill, asphalt, very cobbly loam, gravelly sandy loam fill, extremely cobbly sand fill, sandy loam fill, gravelly sand fill, and cobbly sand fill. These transitions were not clearly depicted in the GPR profile at the depths that they occurred. No other sediment transitions or discrete objects were observed in the GPR results or subsequent excavation.

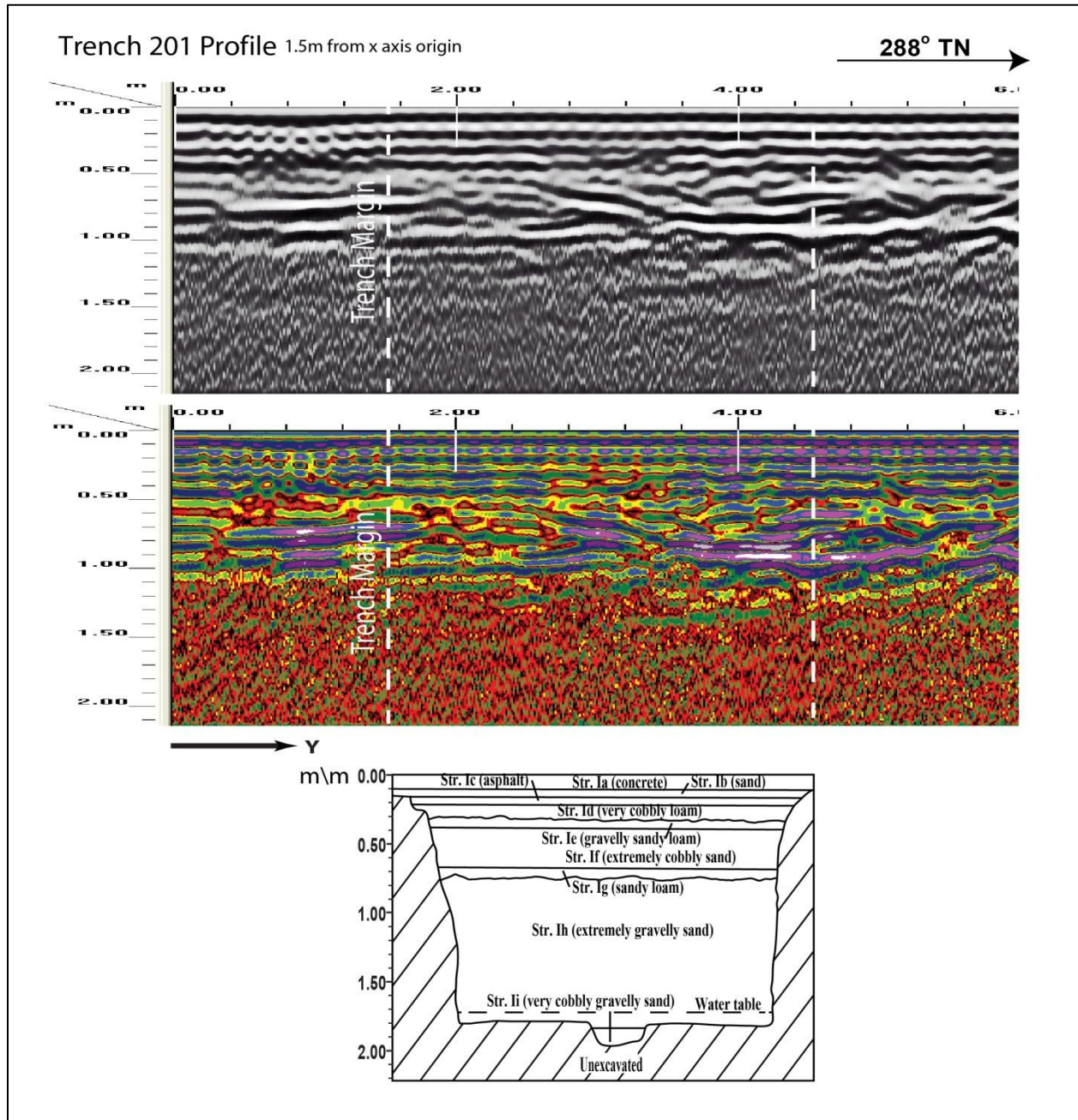


Figure 206. Visual comparison of excavated profile and GPR signal profile of T-201

Test Excavation 202

T-202 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Kona Street, 80.0 m northwest of Kona Street and Kona Iki street intersection. The GPR grid measured 3.0 m by 9.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water drain 3.1 m northeast, water line 4.2 m east. No utilities transected the excavation location.

A review of amplitude slice maps indicated a linear feature but not within excavation boundaries. Reflectivity was relatively uniform throughout the grid and decreased with depth except the linear feature. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 207).

GPR depth profiles for T-202 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 208). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.2 mbs. An anomaly was observed in the profile but was not within excavation boundaries. The maximum depth of clean signal return was approximately 1.0 mbs.

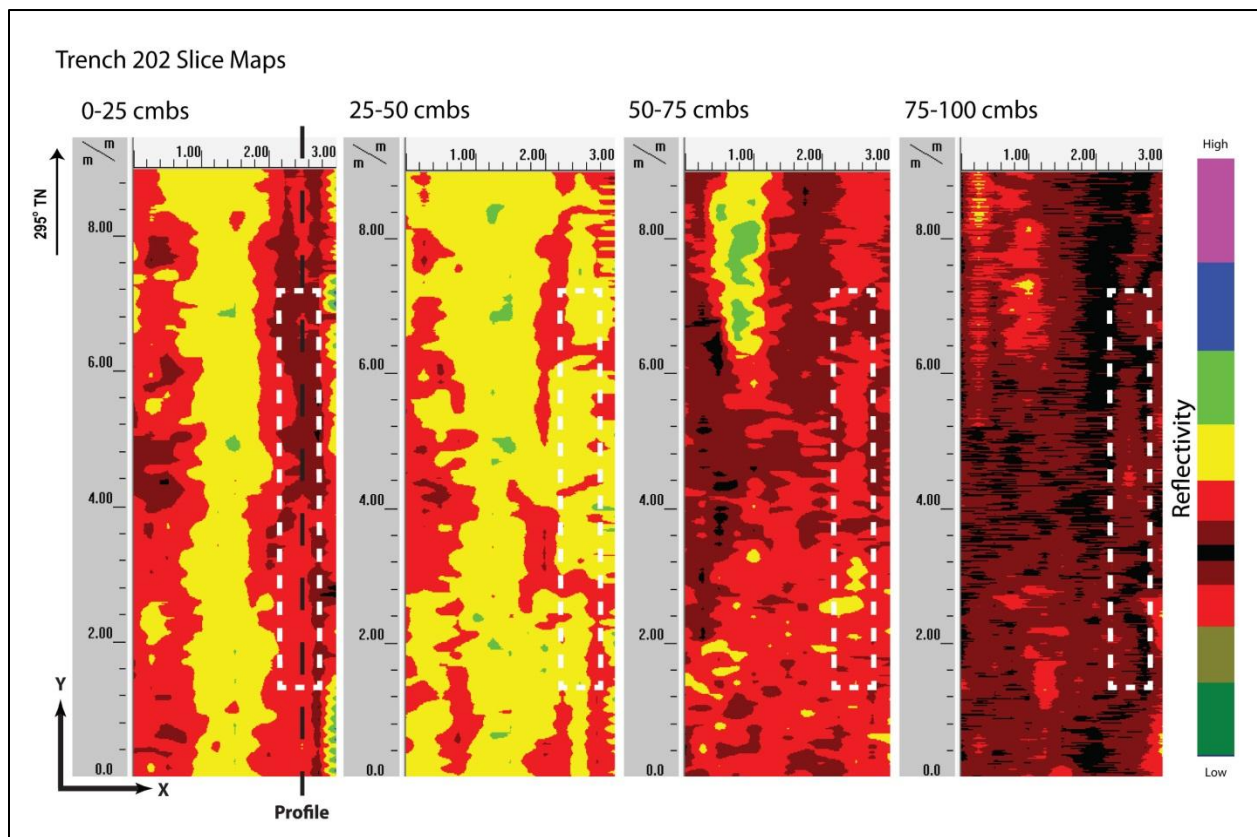


Figure 207. Slice maps of T-202 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 208). Strata Ia to Ie were clearly observed and occurred at the ground-truthed depths. Strata included: concrete, gravelly sandy clay loam fill, extremely gravelly silty sand fill, extremely gravelly silty sand fill, sandy clay fill, extremely gravelly clay fill, and natural silty clay. No discrete objects or other stratigraphic transitions were observed in the GPR results or subsequent excavation.

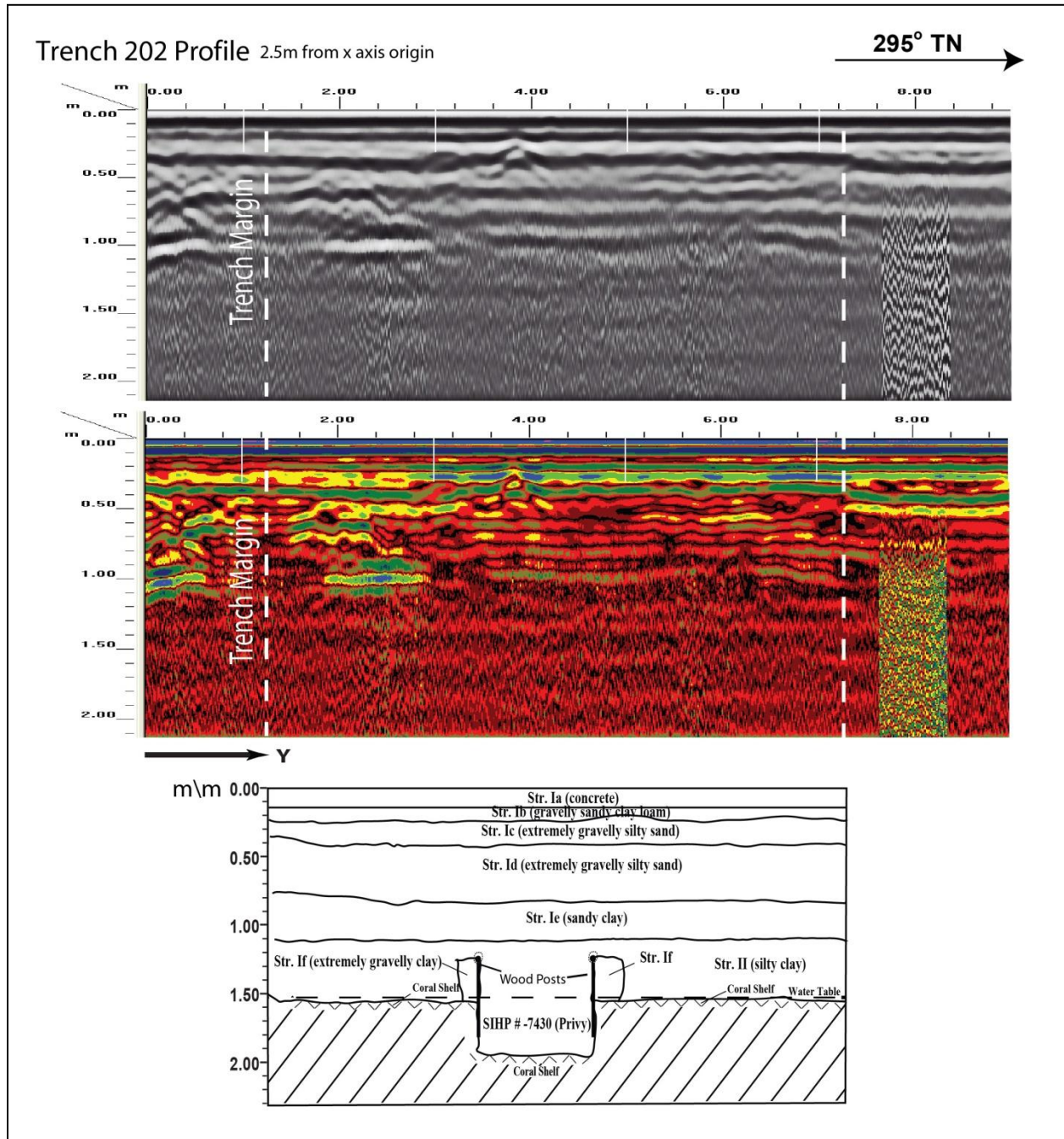


Figure 208. Visual comparison of excavated profile and GPR signal profile of T-202

Test Excavation 202A

T-202A measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Kona Street, 70.0 m northwest of Kona Street and Kona Iki Street intersection. The GPR grid measured 3.0 m by 9.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water line 2.0 m northeast, water drain 3.4 m northeast. No utilities transected the excavation location.

A review of amplitude slice maps indicated linear features but none were encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth except for the feature in the western corner. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.50 mbs (Figure 209).

GPR depth profiles for T-202A identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 210). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.35 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 1.0 mbs.

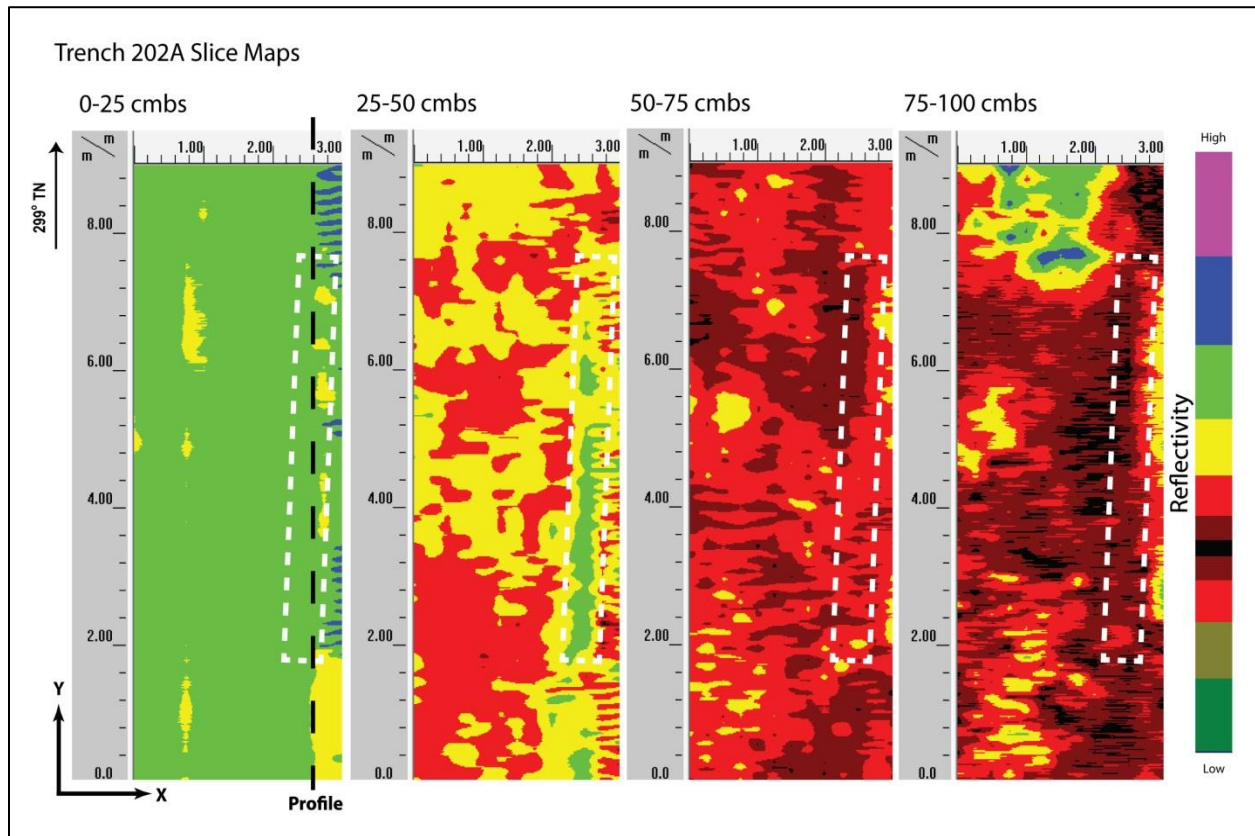


Figure 209. Slice maps of T-202A at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 210). Strata Ia and Ie were clearly observed and occurred at the ground-truthed depths. Strata Ia through Ic were difficult to individually discern, possibly due to the fact that they were thin layers of compacted fill, but based on reflectivity and horizontal banding it was apparent that there were multiple layers of fill events. All other sediment transitions were below the maximum clean signal return depth. No discrete objects were observed in the GPR results or subsequent excavation.

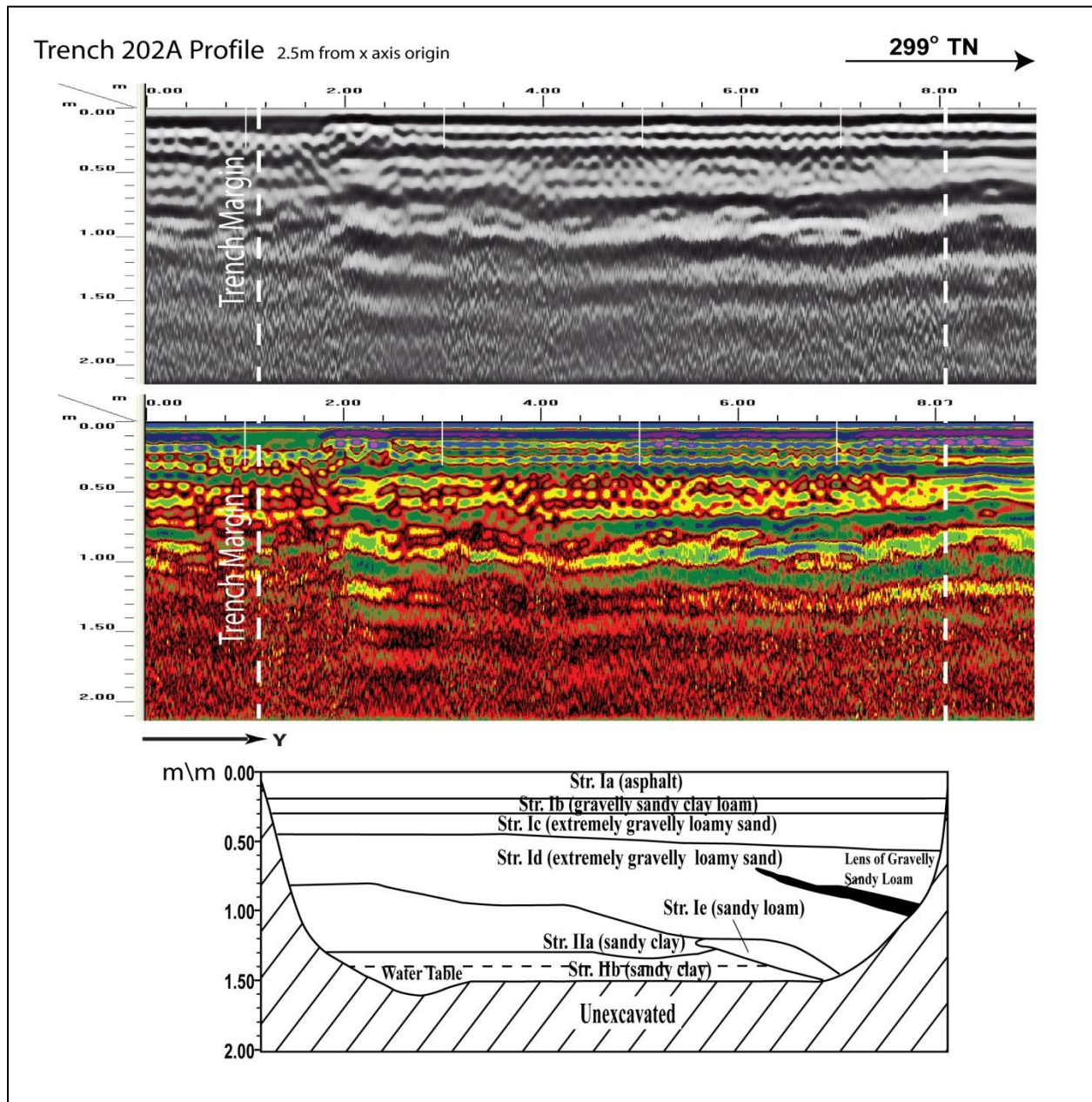


Figure 210. Visual comparison of excavated profile and GPR signal profile of T-202A

Test Excavation 203

T-203 measured 0.9 m by 3.0 m and was oriented northwest to southeast and was located within the sidewalk on Kona Street, 93.0 m northwest of Kona Street and Kona Iki Street intersection. The GPR grid measured 2.0 m by 6.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: electrical line 7.0 m northwest. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 211).

GPR depth profiles for T-203 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 212). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.3 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 1.0 mbs.

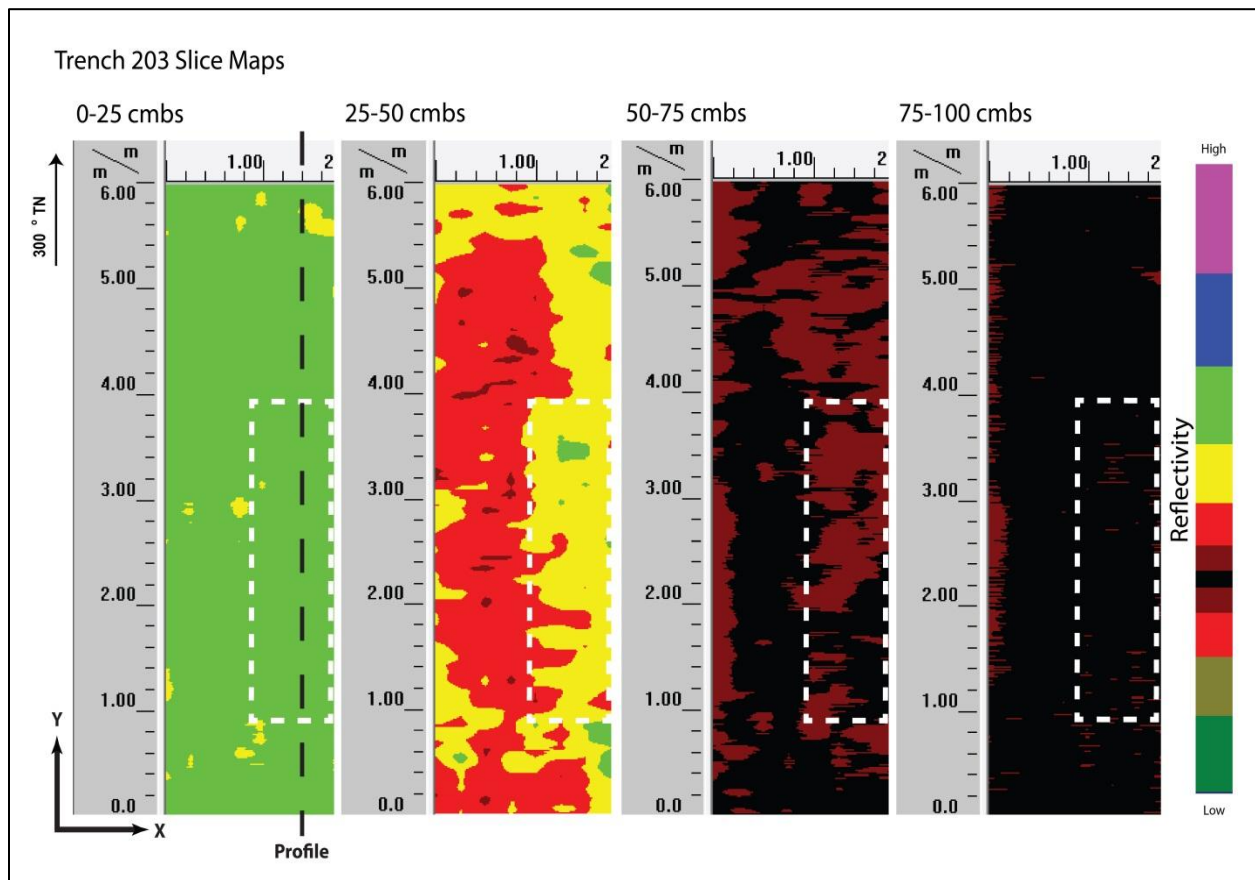


Figure 211. Slice maps of T-203 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 212). Strata Ia to If were clearly observed and occurred at the ground-truthed depths. Strata Ia through Ic may be difficult to individually discern, possibly due to the fact that they were very thin layers of compacted fill, but based on reflectivity and horizontal banding it was apparent that there were multiple layers of fill events. All other sediment transitions were below the maximum clean signal return depth. No discrete objects were observed in the GPR results or subsequent excavation.

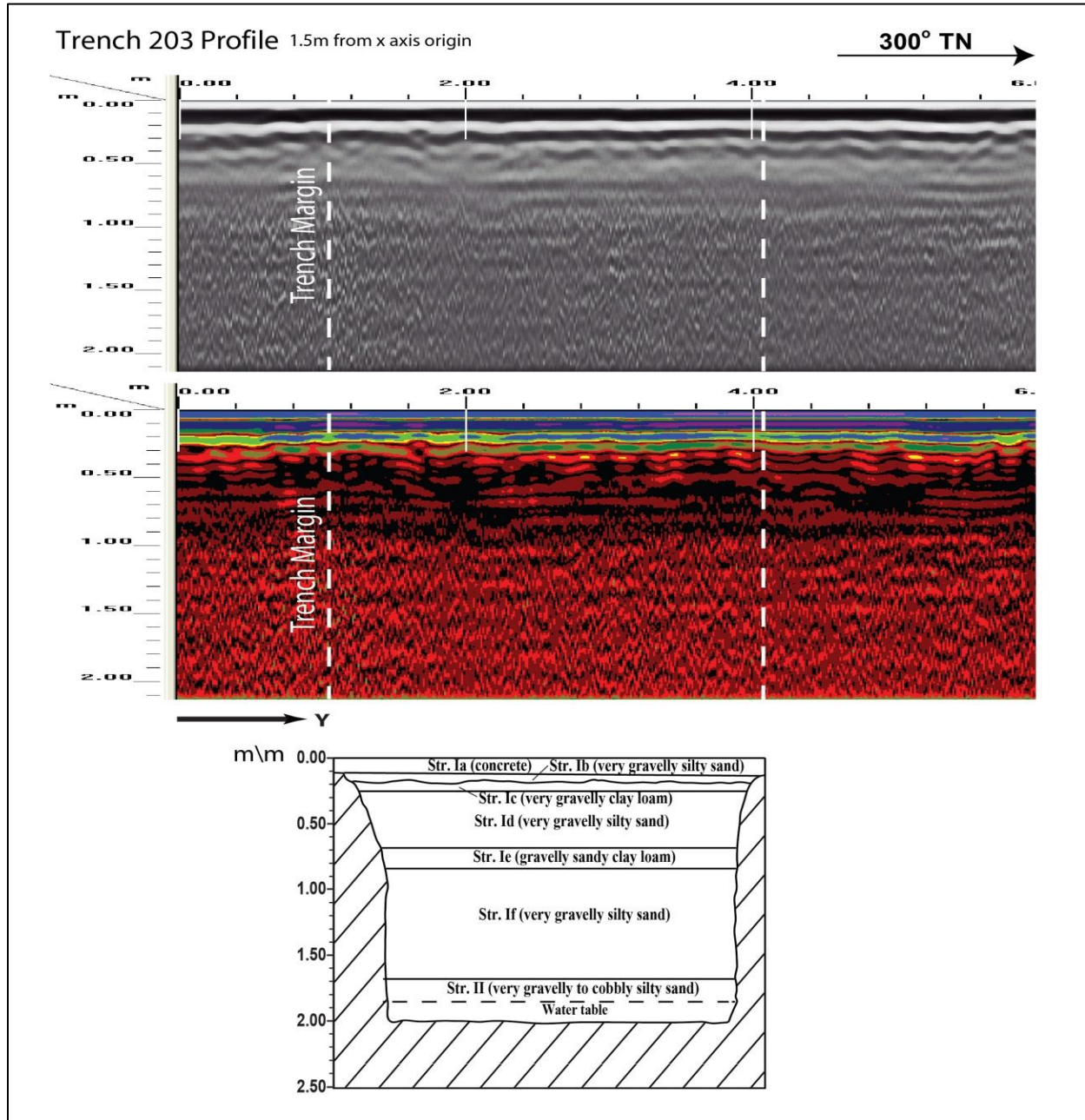


Figure 212. Visual comparison of excavated profile and GPR signal profile of T-203

Test Excavation 204

T-204 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Kona Street, 58.0 m northwest of Kona Street and Kona Iki street intersection. The GPR grid measured 3.0 m by 9.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water line 1.5 m northeast, water drain 3.0 m northeast, electrical line 3.8 m northwest. An abandoned metal utility pipe was encountered 0.5 mbs in the center of the excavation.

A review of amplitude slice maps indicated a linear features which might corresponded to the utility pipe encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 213).

GPR depth profiles for T-204 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 214). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.2 mbs and again at approximately 0.55 mbs. No utilities were observed in the profile although a utility was encountered during excavation. The maximum depth of clean signal return was approximately 1.0 mbs.

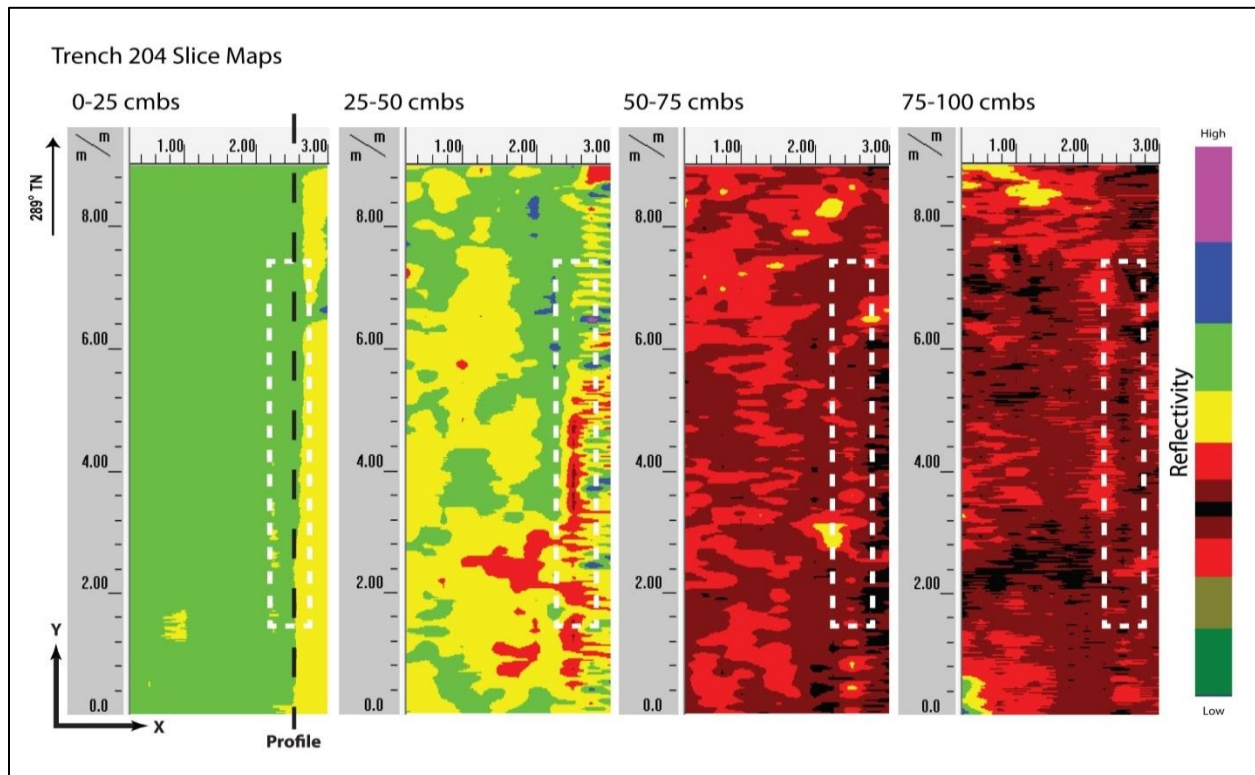


Figure 213. Slice maps of T-204 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 214). Strata Ia to Ic were clearly observed and occurred near the ground-truthed depths. Strata included a layer of asphalt on top of gravelly sandy clay loam fill followed by extremely gravelly silty sand fill. A metal utility was found 0.5 mbs. This pipe did not show up on the profile or slice maps. This may be due to the fact that the pipe was empty. No other discrete objects or stratigraphic transitions were observed in the GPR results or subsequent excavation.

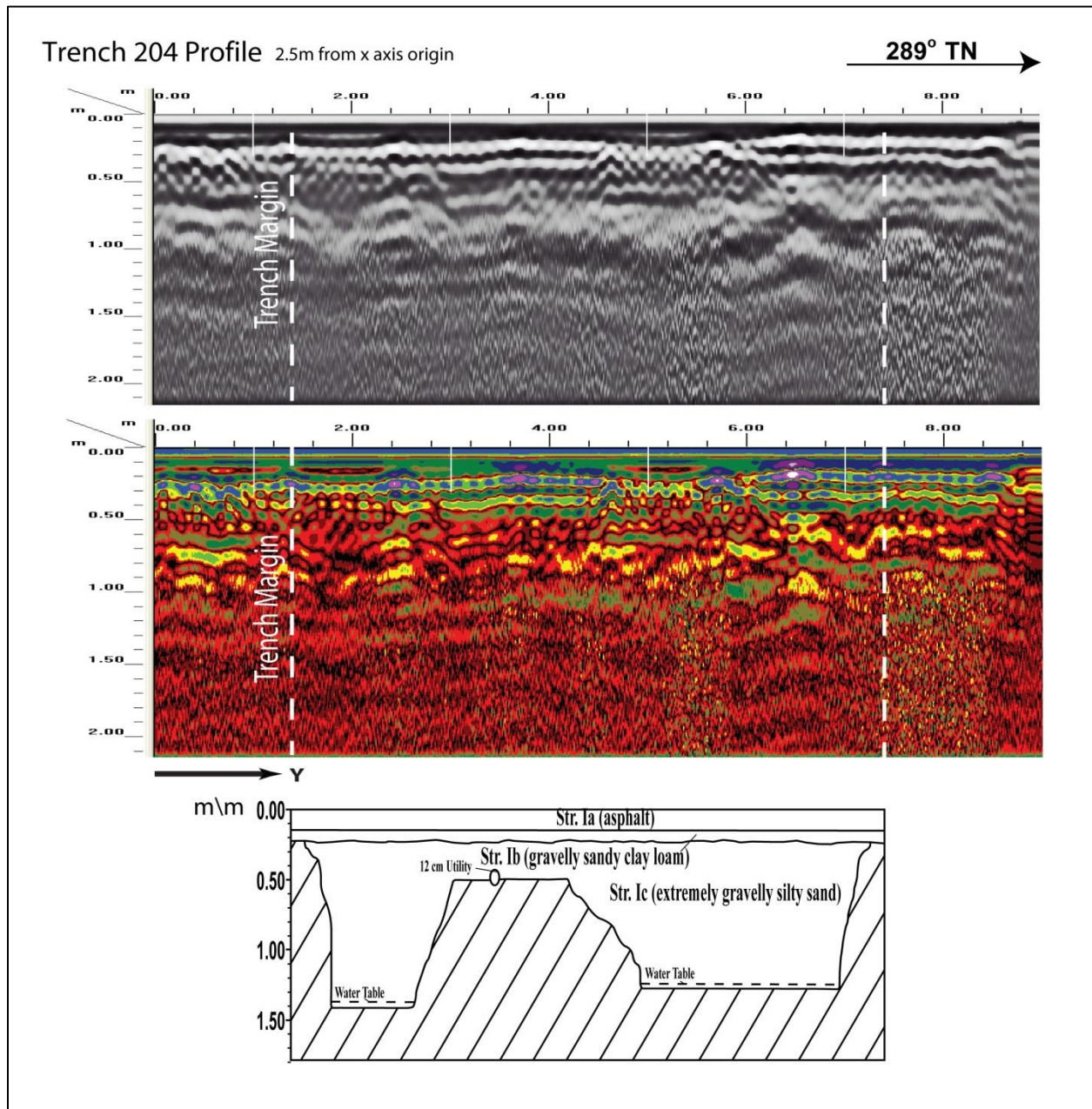


Figure 214. Visual comparison of excavated profile and GPR signal profile of T-204

Test Excavation 205

T-205 measured 0.9 m by 3.0 m and was oriented northwest to southeast, and was located within the sidewalk on Kona Street, 35.0 m west of Kona Street and Kona Iki Street intersection. The GPR grid measured 2.0 m by 6.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. According to PB CADD, there were no utilities within close proximity of the excavation. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs (Figure 215).

GPR depth profiles for T-205 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 216). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.25 mbs. An anomaly was present however it was not within excavation boundaries. No utilities were observed in the excavation unit. The maximum depth of clean signal return was approximately 1.0 mbs.

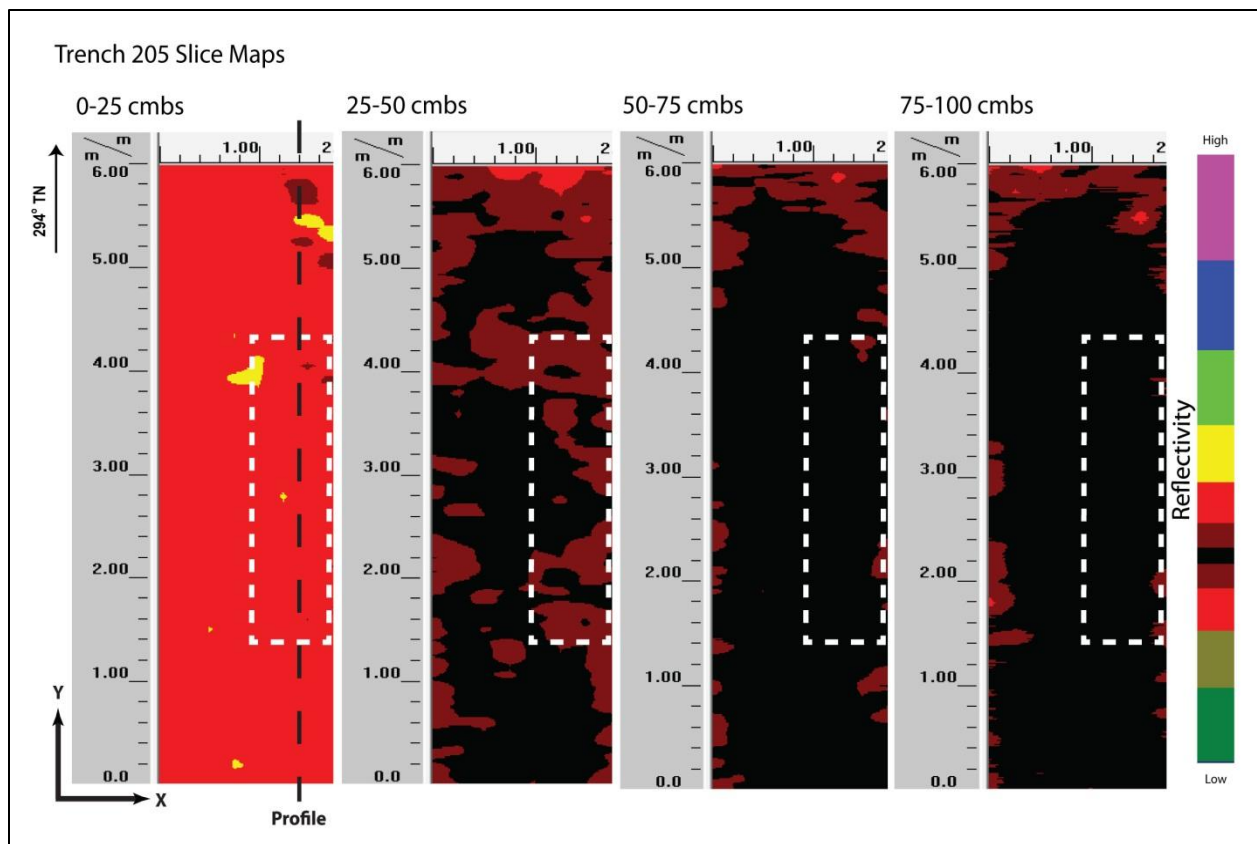


Figure 215. Slice maps of T-205 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 216). Strata Ia and Ib were clearly observed and occurred near the ground-truthed depths. Strata included: concrete, gravelly sandy clay loam fill, very gravelly silty sand fill, very gravelly to cobbly silty sand fill, and natural silty clay. No discrete objects or other stratigraphic transitions were observed in the GPR results or subsequent excavation.

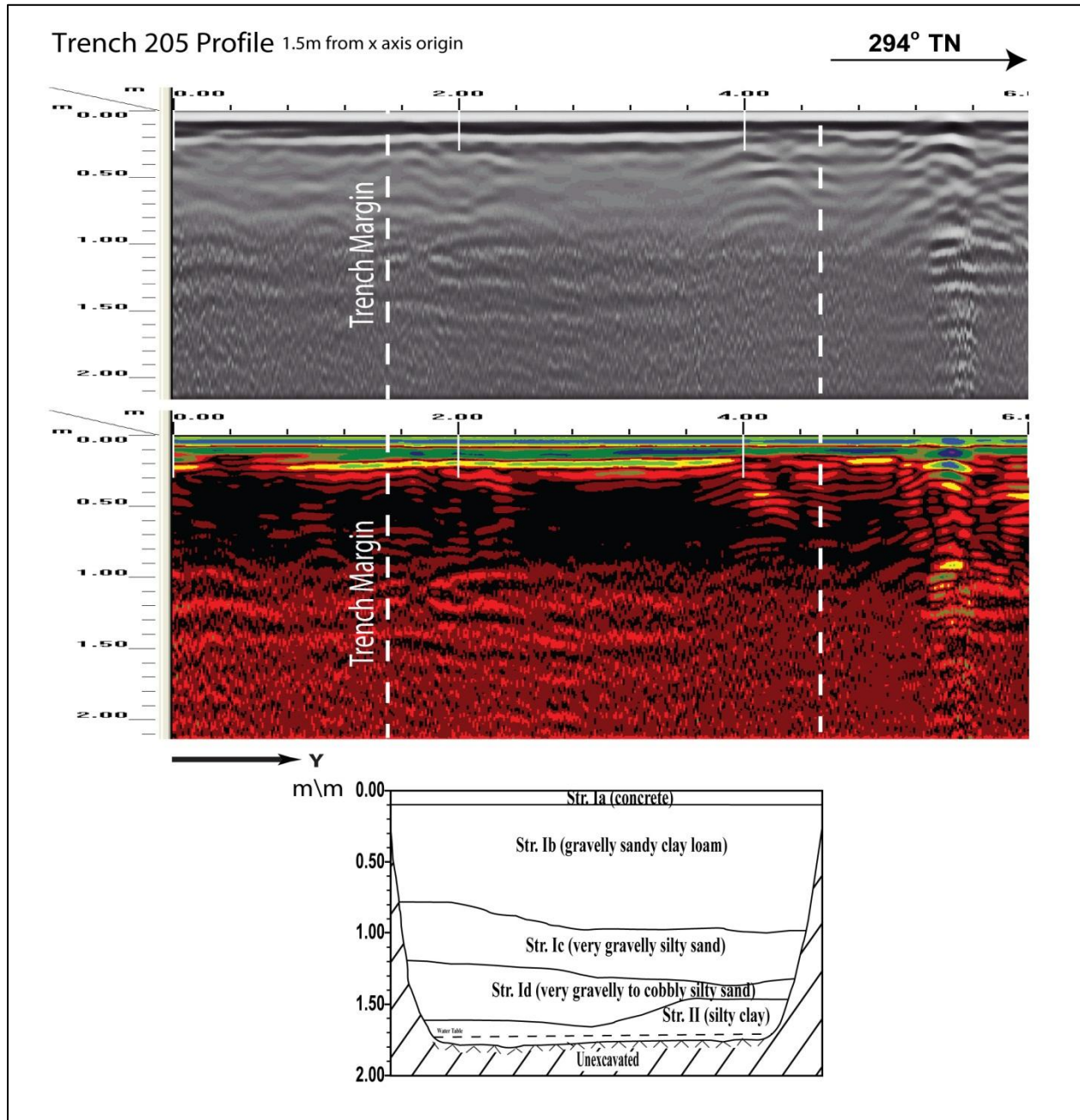


Figure 216. Visual comparison of excavated profile and GPR signal profile of T-205

Test Excavation 207

T-207 measured 0.9 m by 3.0 m and was oriented northwest to southeast and was located within the sidewalk on Kona Street, 15.0 m north of Kona Street and Kona Iki Street intersection. The GPR grid measured 2.0 m by 6.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: electrical line 0.9 m southwest. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs (Figure 217).

GPR depth profiles for T-207 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 218). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.3 mbs. No utilities observed in the profile. The maximum depth of clean signal return was approximately 1.0 mbs.

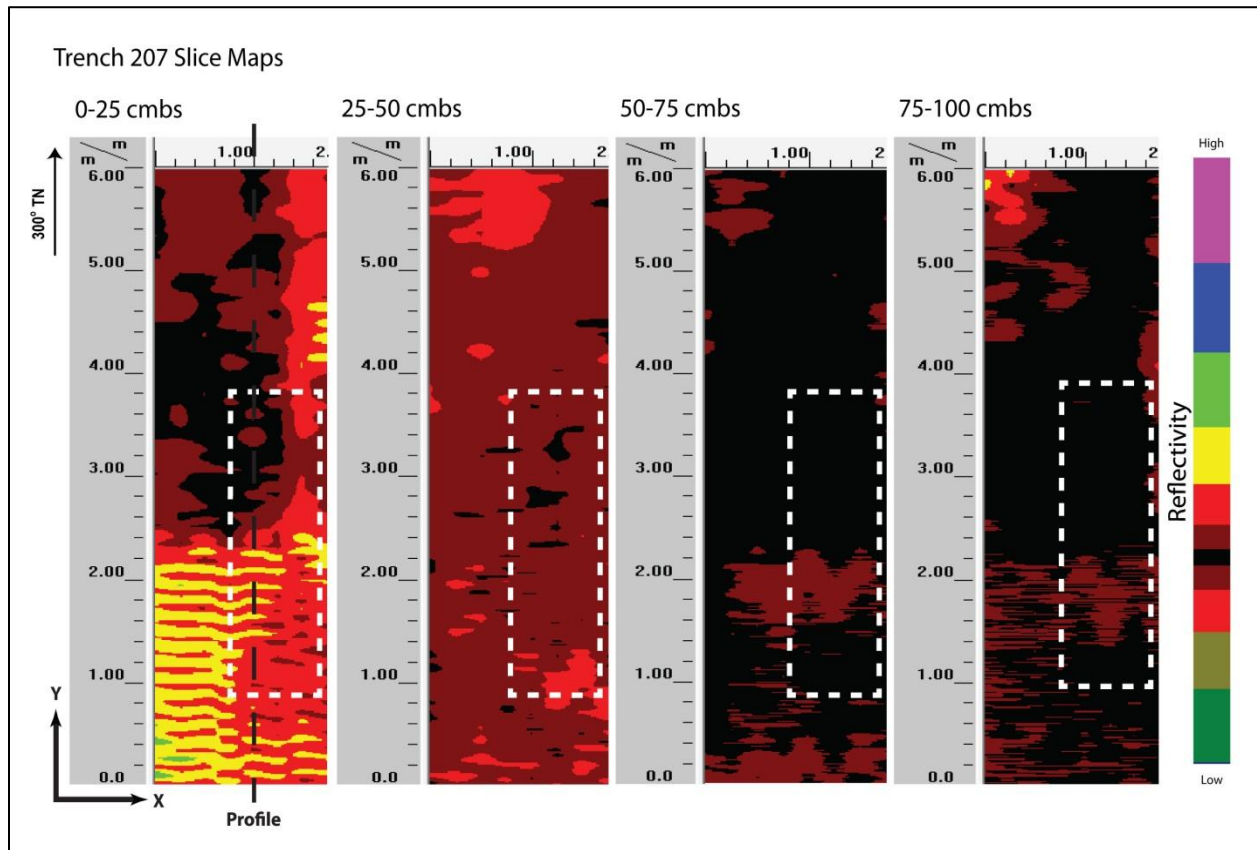


Figure 217. Slice maps of T-207 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 218). Strata Ia to IIa were clearly observed and occurred at the ground-truthed depths. Strata Ia through Ic may be difficult to individually discern, possibly due to the fact that they were very thin layers of compacted fill, but based on reflectivity and horizontal banding it was apparent that there were multiple layers of fill events. All other sediment transitions were below the maximum clean signal return depth. No discrete objects were observed in the GPR results or subsequent excavation.

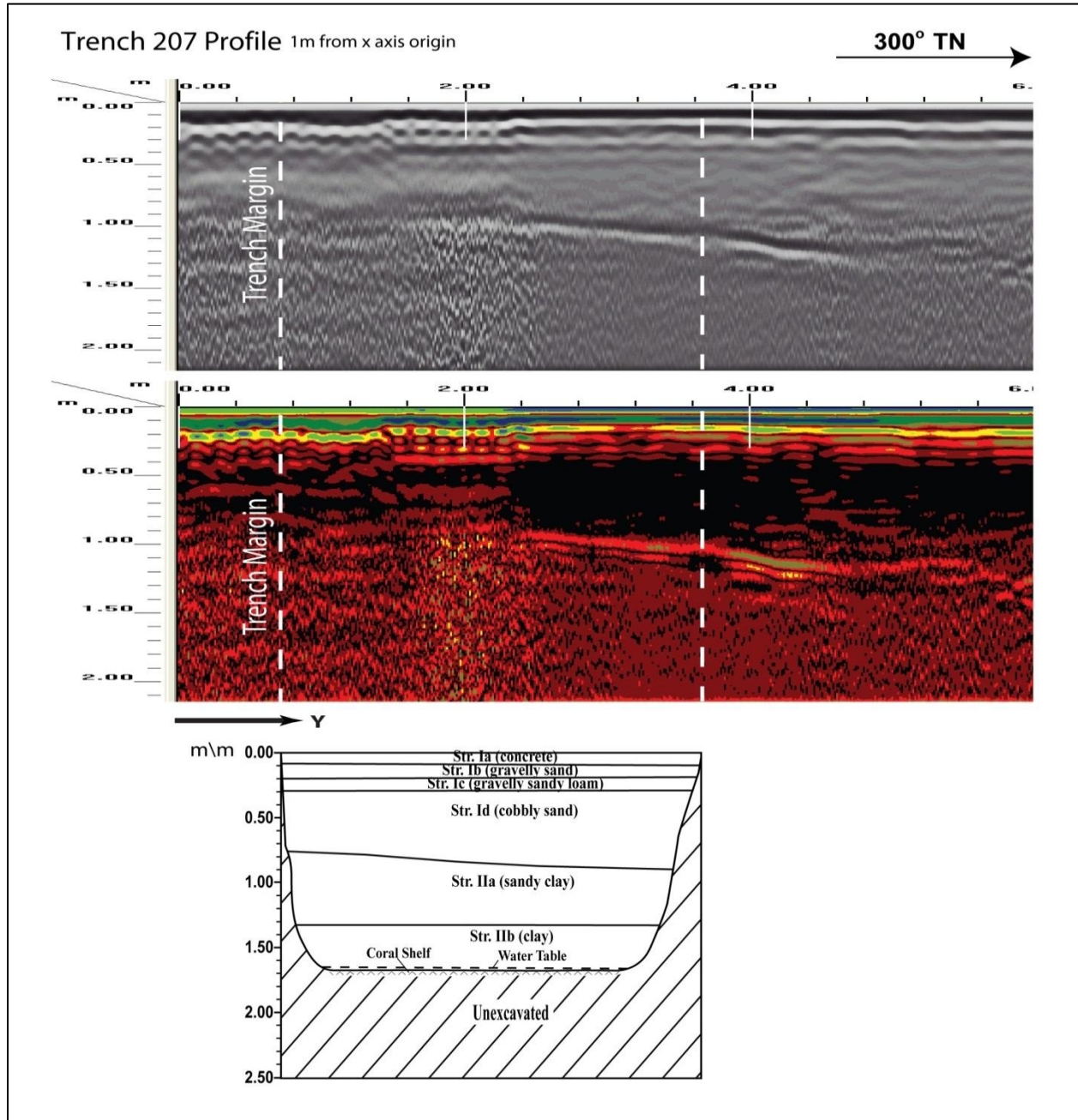


Figure 218. Visual comparison of excavated profile and GPR signal profile of T-207

Test Excavation 208

T-208 measured 0.9 m by 3.0 m and was oriented northwest to southeast and was located within the road cut of Kona Street, 15.0 m southeast of Kona Street and Kona Iki Street intersection. The GPR grid measured 2.0 m by 4.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. According to PB CADD, there were no utilities within close proximity of the excavation. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.75 mbs (Figure 219).

GPR depth profiles for T-208 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 220). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.55 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 0.9 mbs.

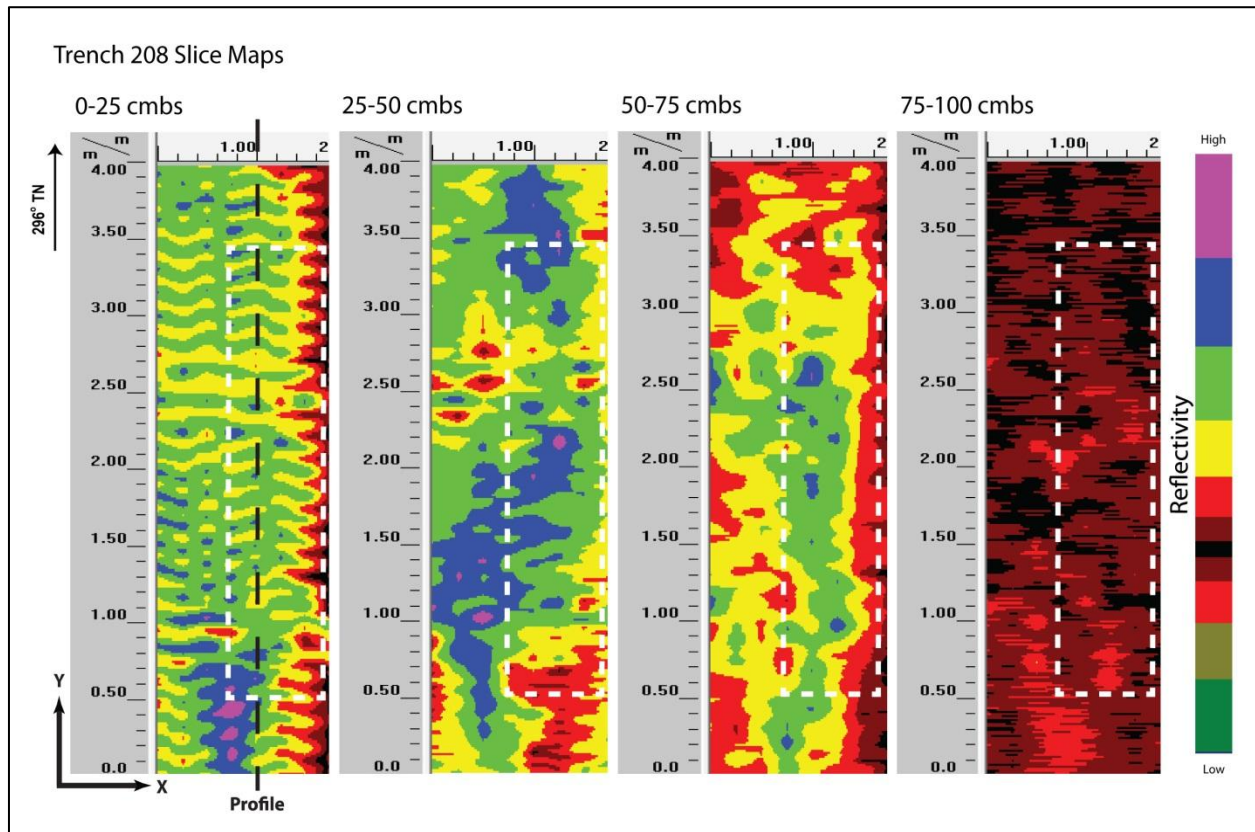


Figure 219. Slice maps of T-208 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 220). Strata Ia to Ie were clearly observed and occurred near the ground-truthed depths. Strata Ia through Id may be difficult to individually discern, possibly due to the fact that they were very thin layers of compacted fill, but based on reflectivity and horizontal banding it was apparent that there were multiple layers of fill events. All other sediment transitions were below the maximum clean signal return depth. No discrete objects were observed in the GPR results or subsequent excavation.

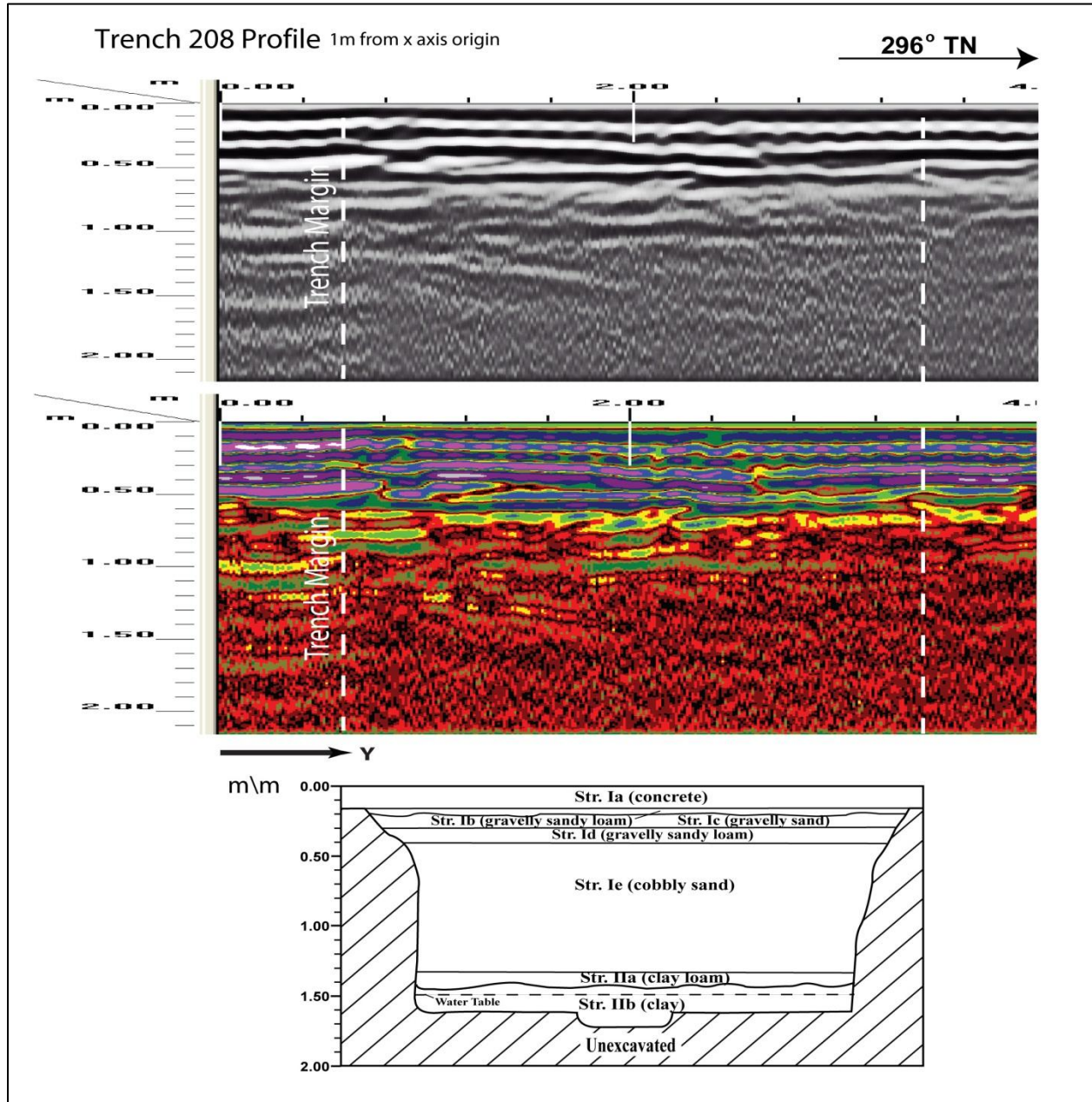


Figure 220. Visual comparison of excavated profile and GPR signal profile of T-208

Test Excavation 209

T-209 measured 0.9 m by 3.0 m and was oriented northwest to southeast and was located within the road cut of Kona Street, 15.0 m southeast of Kona Street and Kona Iki Street intersection. The GPR grid measured 3.0 m by 6.0 m with 50.0 cm spacing between Y transects and 1.0 m spacing between X transects. According to PB CADD, there were no utilities within close proximity of the excavation. No utilities transected the GPR grid or the excavation location.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.75 mbs (Figure 221).

GPR depth profiles for T-209 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 222). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.45 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 0.85 mbs.

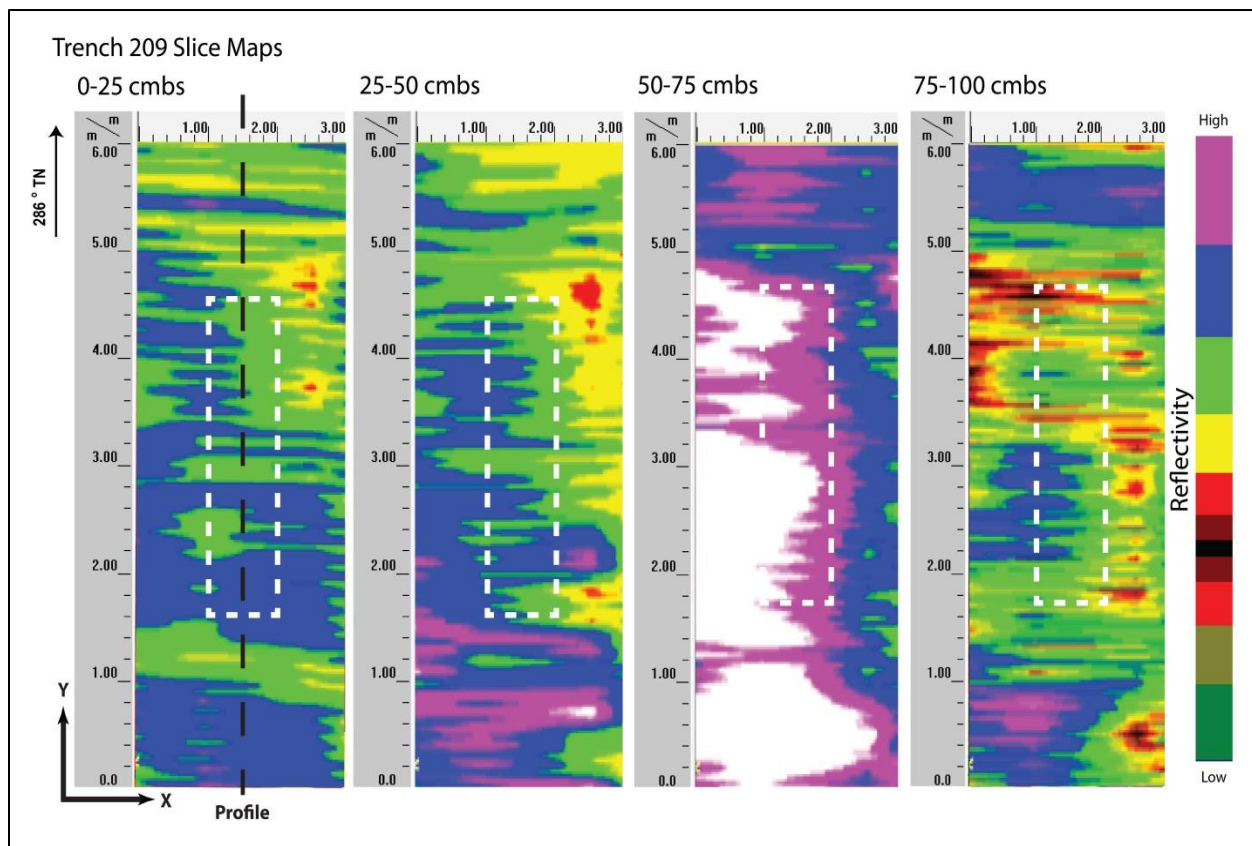


Figure 221. Slice maps of T-209 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 222). Strata Ia through Ie were clearly observed and occurred at the ground-truthed depths. Strata included: concrete, gravelly silt fill, asphalt, extremely gravelly sand, silt loam fill, natural silt loam, and sand with clay. No discrete objects or other stratigraphic transitions were observed in the GPR results or subsequent excavation.

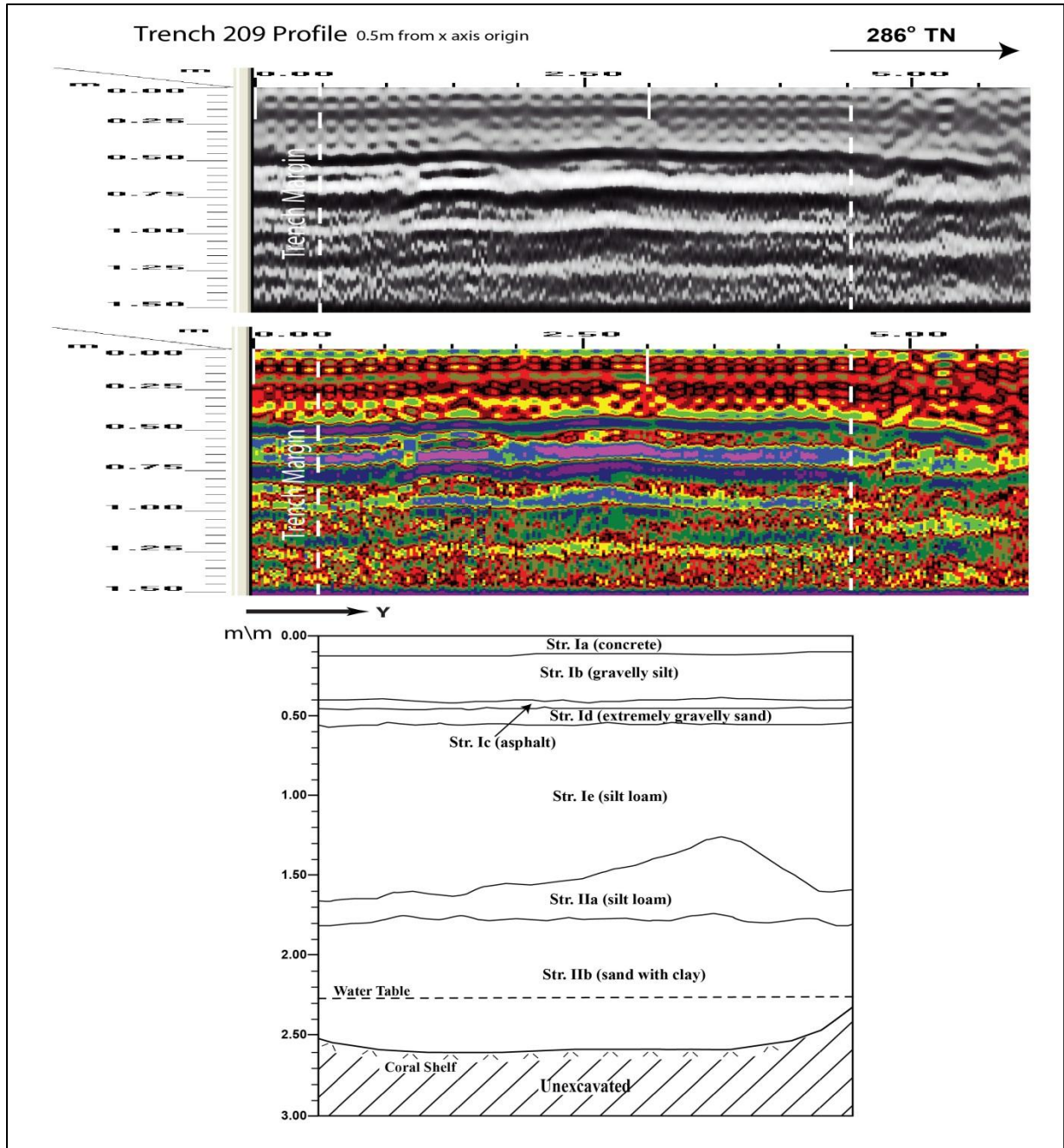


Figure 222. Visual comparison of excavated profile and GPR signal profile of T-209

Test Excavation 210

Excavation 210 measured 0.8 m by 6.0 metres and was oriented northwest to southeast and was located within a warehouse 37.0 m east of Kona Street and Kona Iki street intersection, 9.0 m north of Kona Street. The GPR grid measured 3.0 m by 6.0 m and with 50.0 cm spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: electrical line 9.0 m southwest. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 223).

GPR depth profiles for T-210 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 224). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.45 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 0.90 mbs.

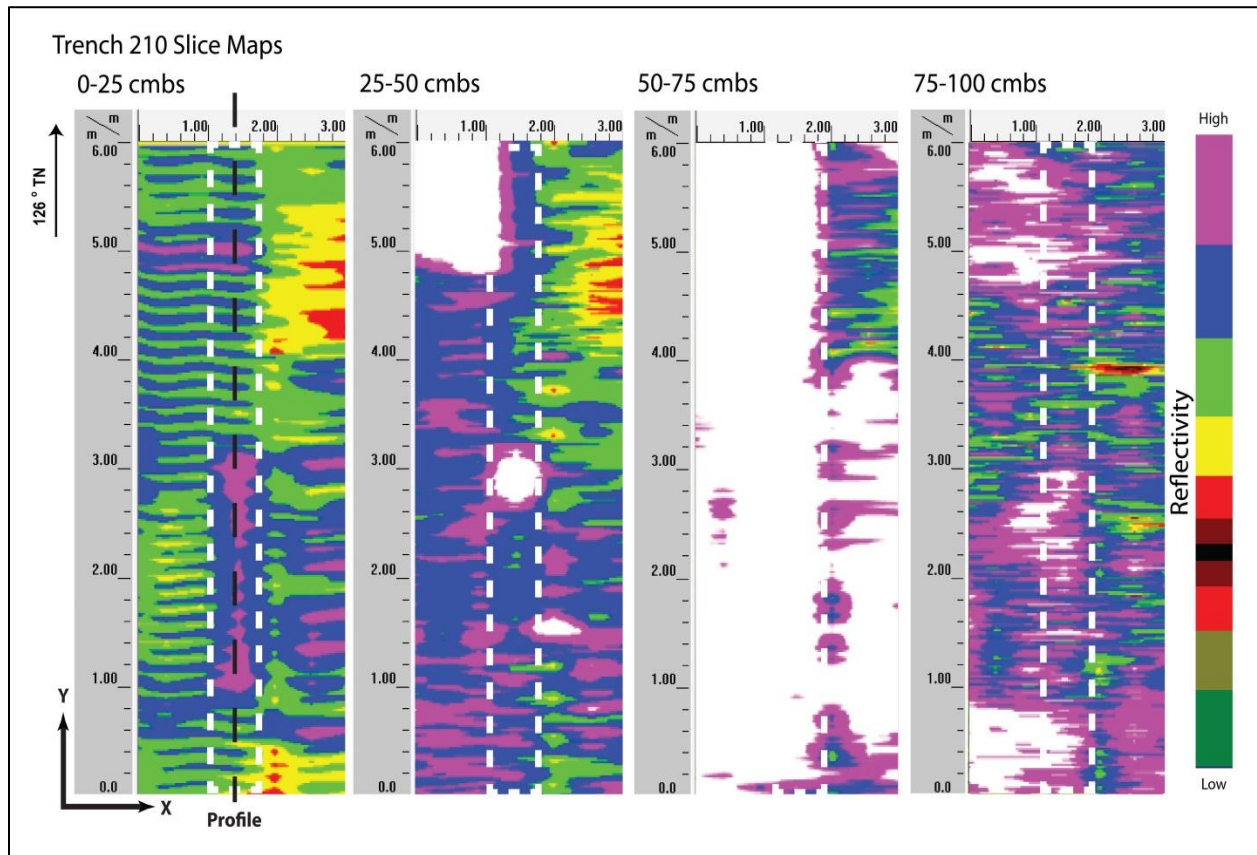


Figure 223. Slice maps of T-210 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 224). Strata Ia to Ic were clearly observed and occurred near the ground-truthed depths. Strata Ia through Ic may be difficult to individually discern, possibly due to the fact that they were very thin layers of compacted fill, but based on reflectivity and horizontal banding it was apparent that there were multiple layers of fill events. No discrete objects were observed in the GPR results or subsequent excavation.

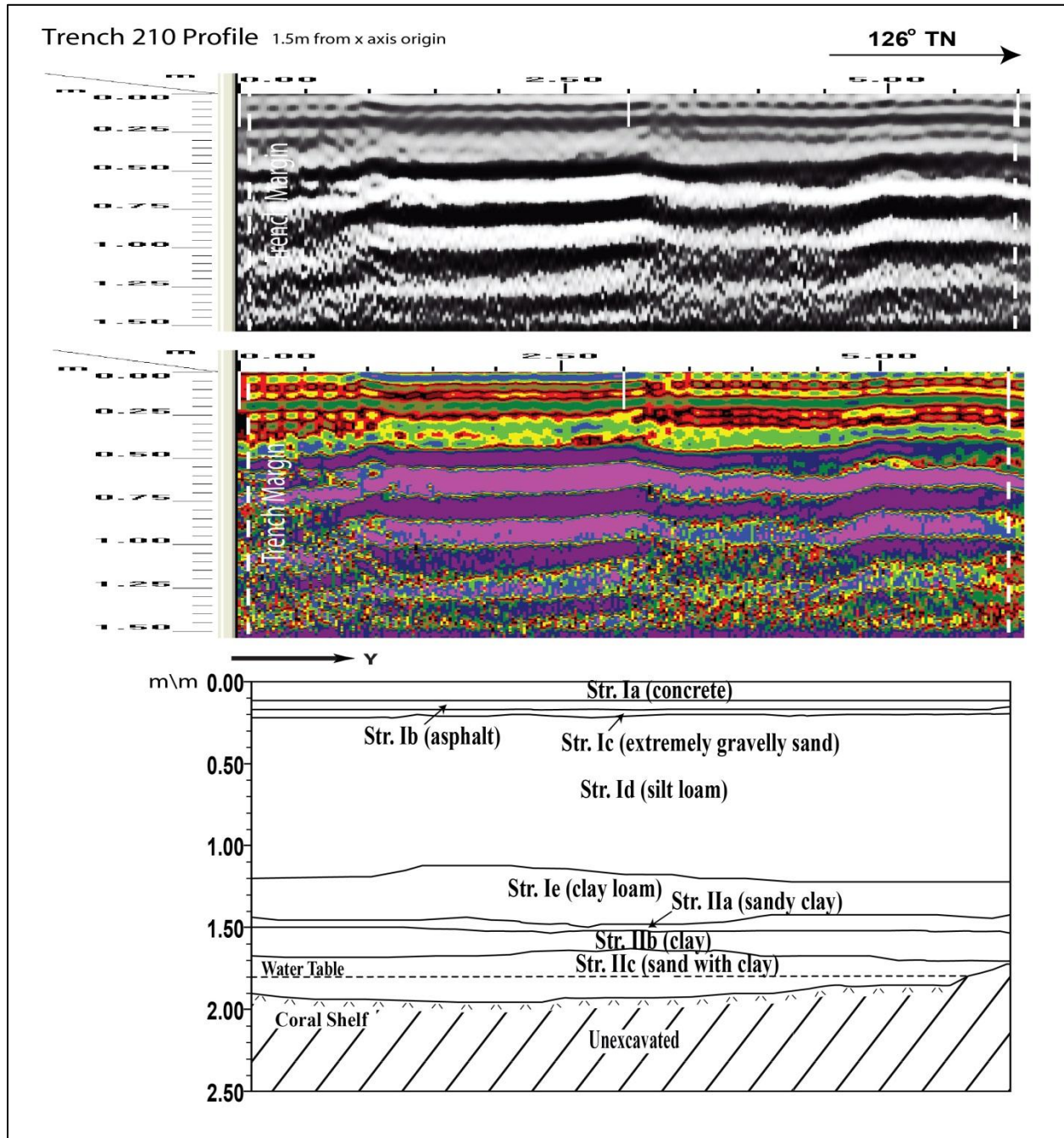


Figure 224. Visual comparison of excavated profile and GPR signal profile of T-210

Test Excavation 211

T-211 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within a warehouse 58.0 m east of Kona street and Kona Iki Street intersection, 11.0 m northeast of Kona Street. The GPR grid measured 3.0 m by 6.0 m with 50.0 centim spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water line 9.0 m southwest. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.75 mbs (Figure 225).

GPR depth profiles for T-211 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 226). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.5 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 0.5 mbs.

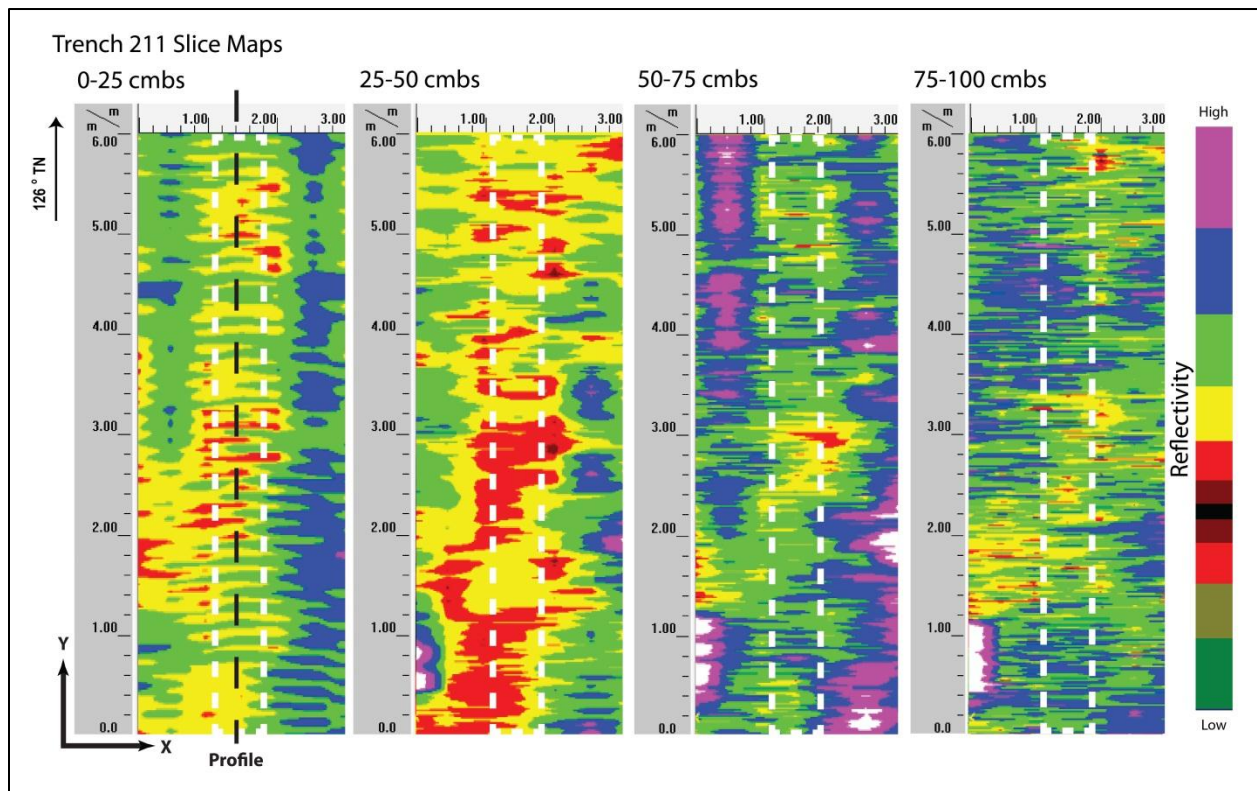


Figure 225. Slice maps of T-211 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a weak correlation in stratigraphic transitions (Figure 226). Strata included: concrete, silt loam fill, asphalt, extremely gravelly sand, silt loam fill, gravelly silt loam fill, natural silt loam, and natural clay. These transitions were not clearly depicted in the GPR profile at the depths that they occurred. No other sediment transitions or discrete objects were observed in the GPR results or subsequent excavation.

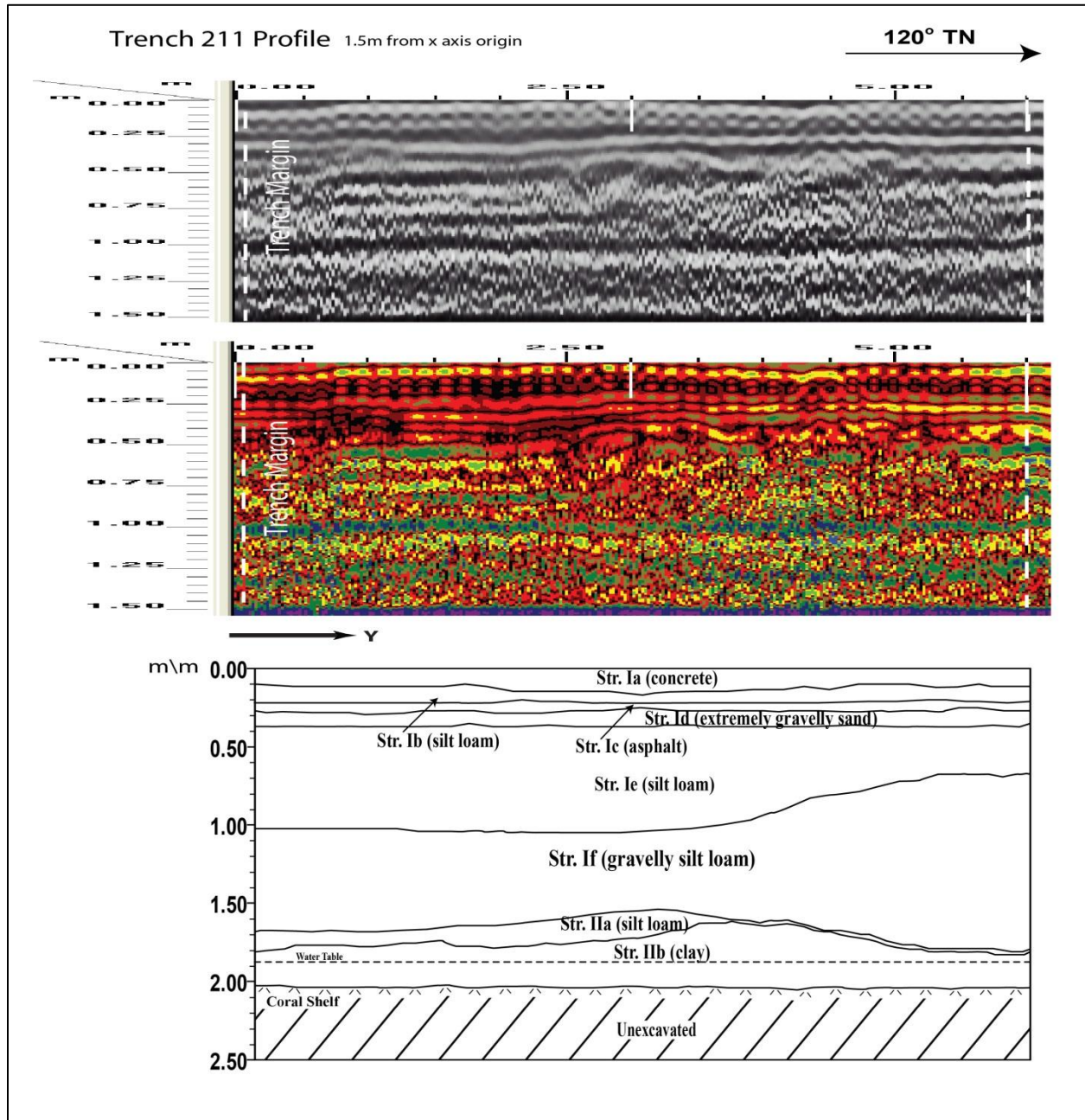


Figure 226. Visual comparison of excavated profile and GPR signal profile of T-211

Test Excavation 212

T-212 measured 0.9 m by 3.0 m and was oriented northwest to southeast and was located within the sidewalk on Kona Street, 68.0 m southeast of Kona Steet and Kona Iki Street intersection. The GPR grid measured 2.0 m by 7.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: electrical cable 4.7 m northeast. No utilities transected the excavation location.

A review of amplitude slice maps indicated a linear feature at the northwest end but was not encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth except for the linear feature. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 227).

GPR depth profiles for T-212 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 228). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.4 mbs. An anomaly was observed in the profile but was not encountered during excavation. The maximum depth of clean signal return was approximately 0.8 mbs.

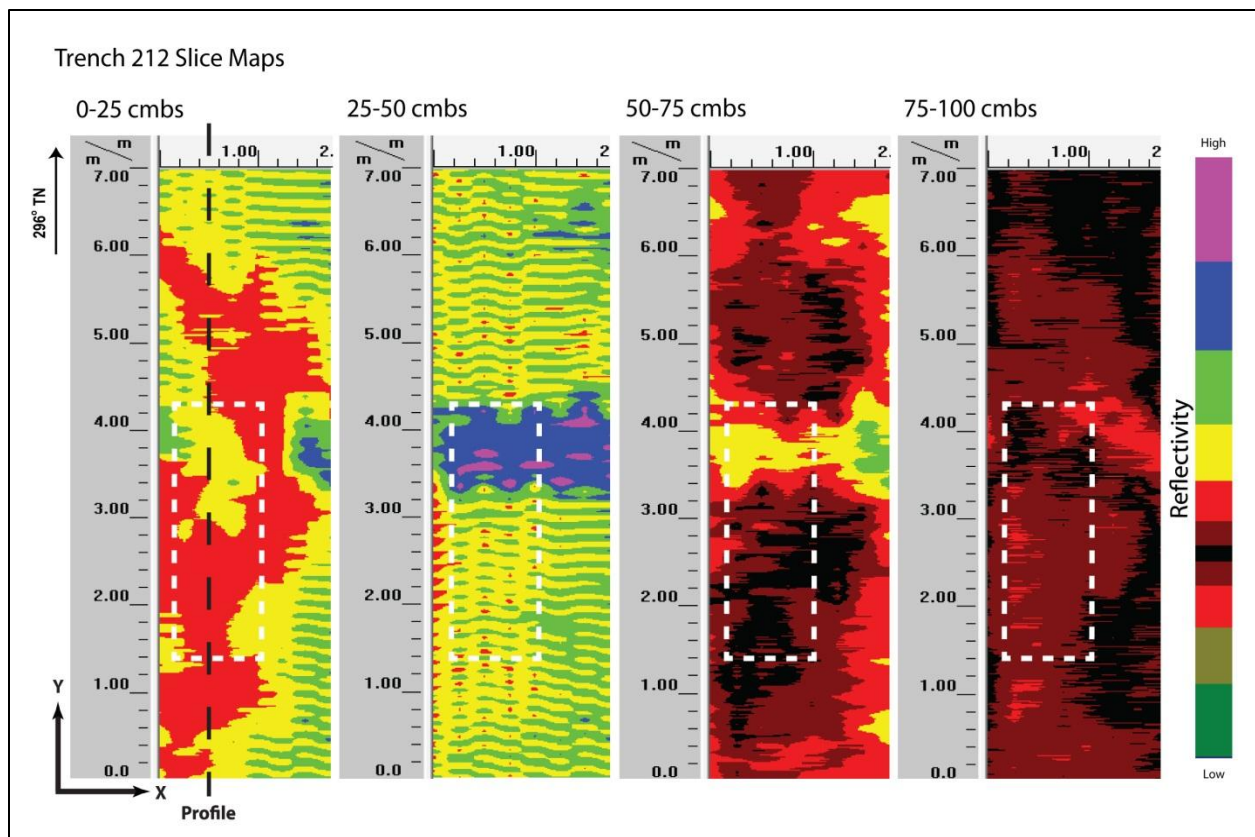


Figure 227. Slice maps of T-212 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 228). Strata Ia to Ic were clearly observed and occurred near the ground-truthed depths. A textural change was observed around 0.5 mbs and may represent extremely gravelly silty sand. No discrete objects were observed in the GPR results or subsequent excavation.

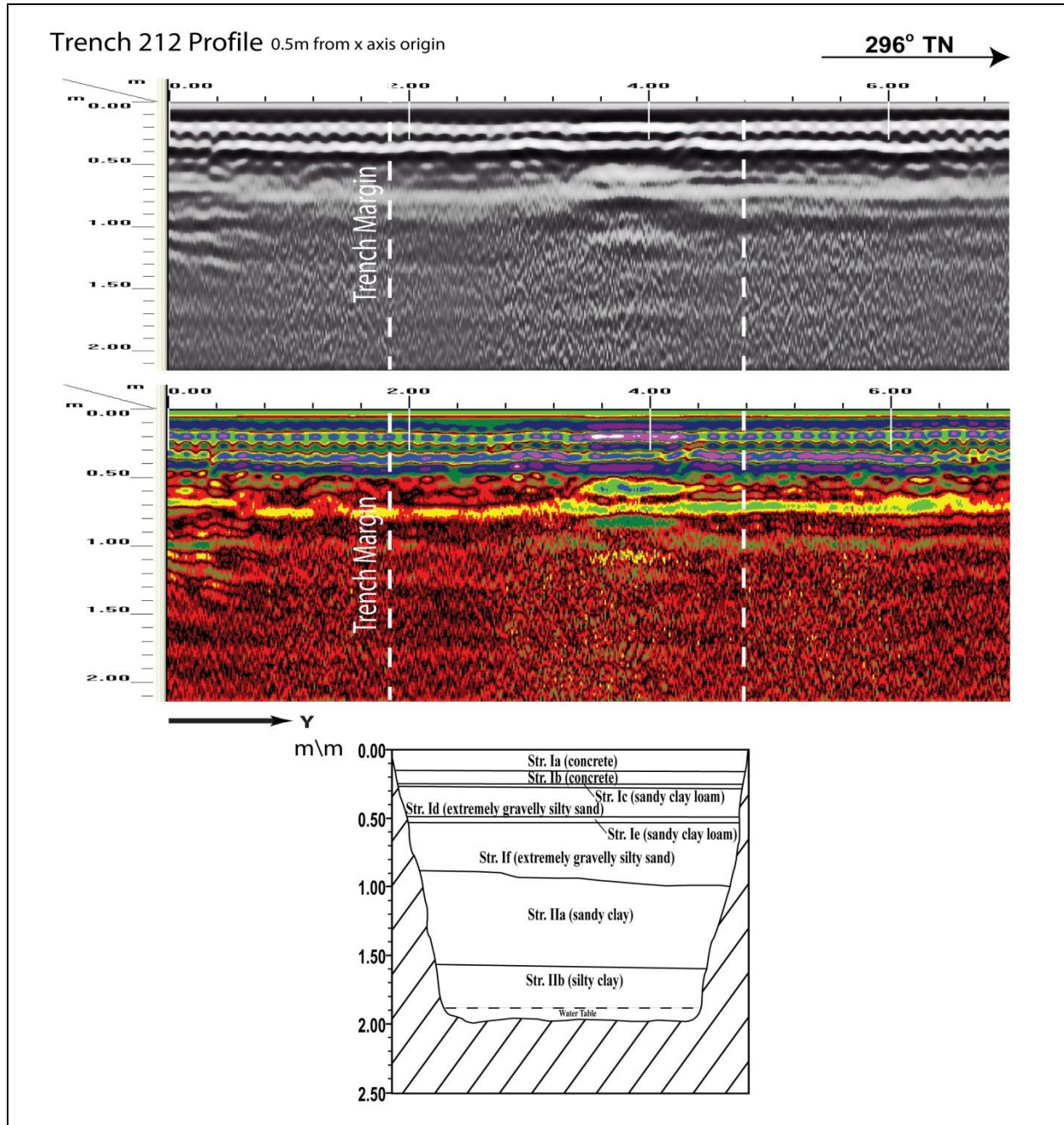


Figure 228. Visual comparison of excavated profile and GPR signal profile of T-212

Test Excavation 213

T-213 measured 0.9 m by 3.0 m and was oriented northwest to southeast and was located within a warehouse 65.0 m east of Kona Street and Kona Iki Street intersection, 6.5 m north of Kona Street. The GPR grid measured 2.0 m by 6.0 m with 50.0 cm spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: electrical line 5.7 m southwest. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.75 mbs (Figure 229).

GPR depth profiles for T-213 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 230). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.5 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 0.75 mbs.

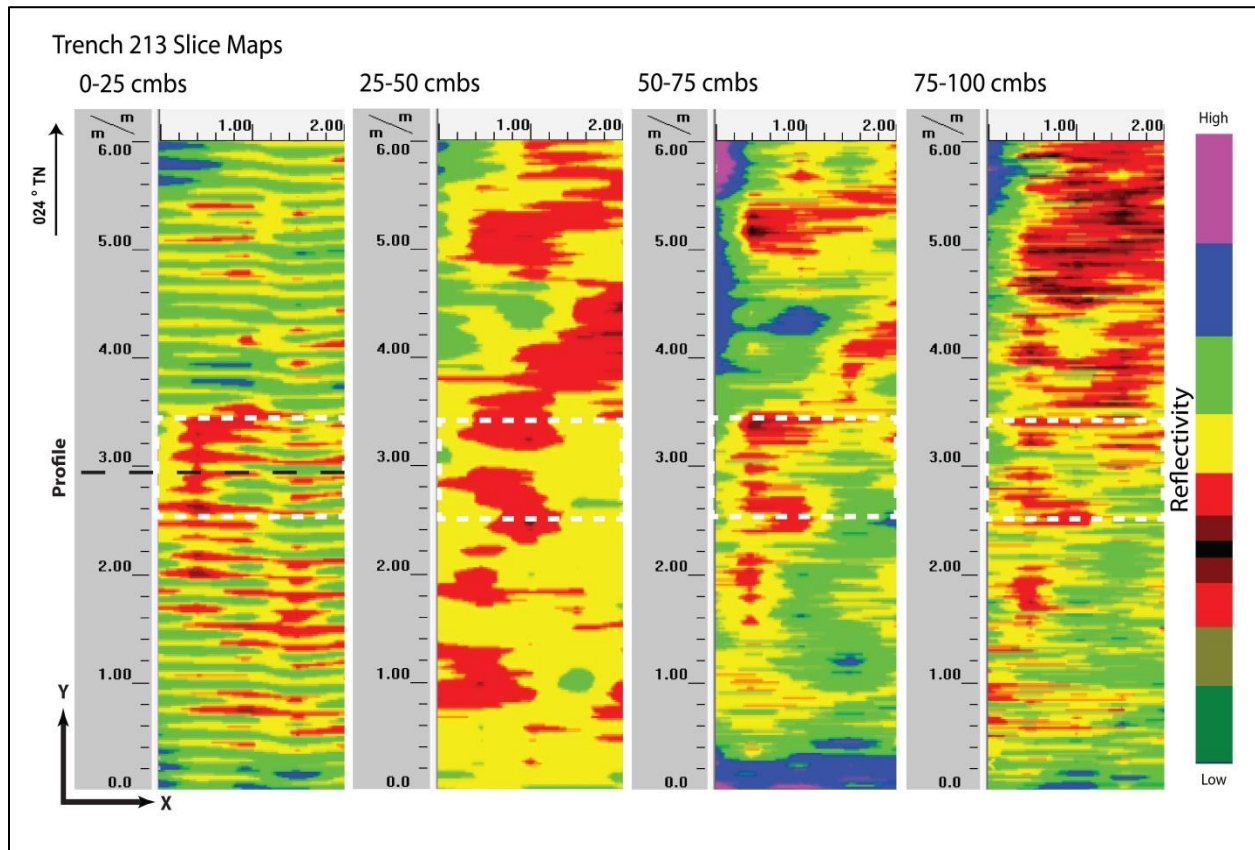


Figure 229. Slice maps of T-213 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a weak correlation in stratigraphic transitions (Figure 230). Strata included: concrete, silt loam fill, asphalt, extremely gravelly sand, cobbly loam fill, cobbly to stony loam fill, and cobbles and boulders. These transitions were not clearly depicted in the GPR profile at the depths that they occurred. No other sediment transitions or discrete objects were observed in the GPR results or subsequent excavation.

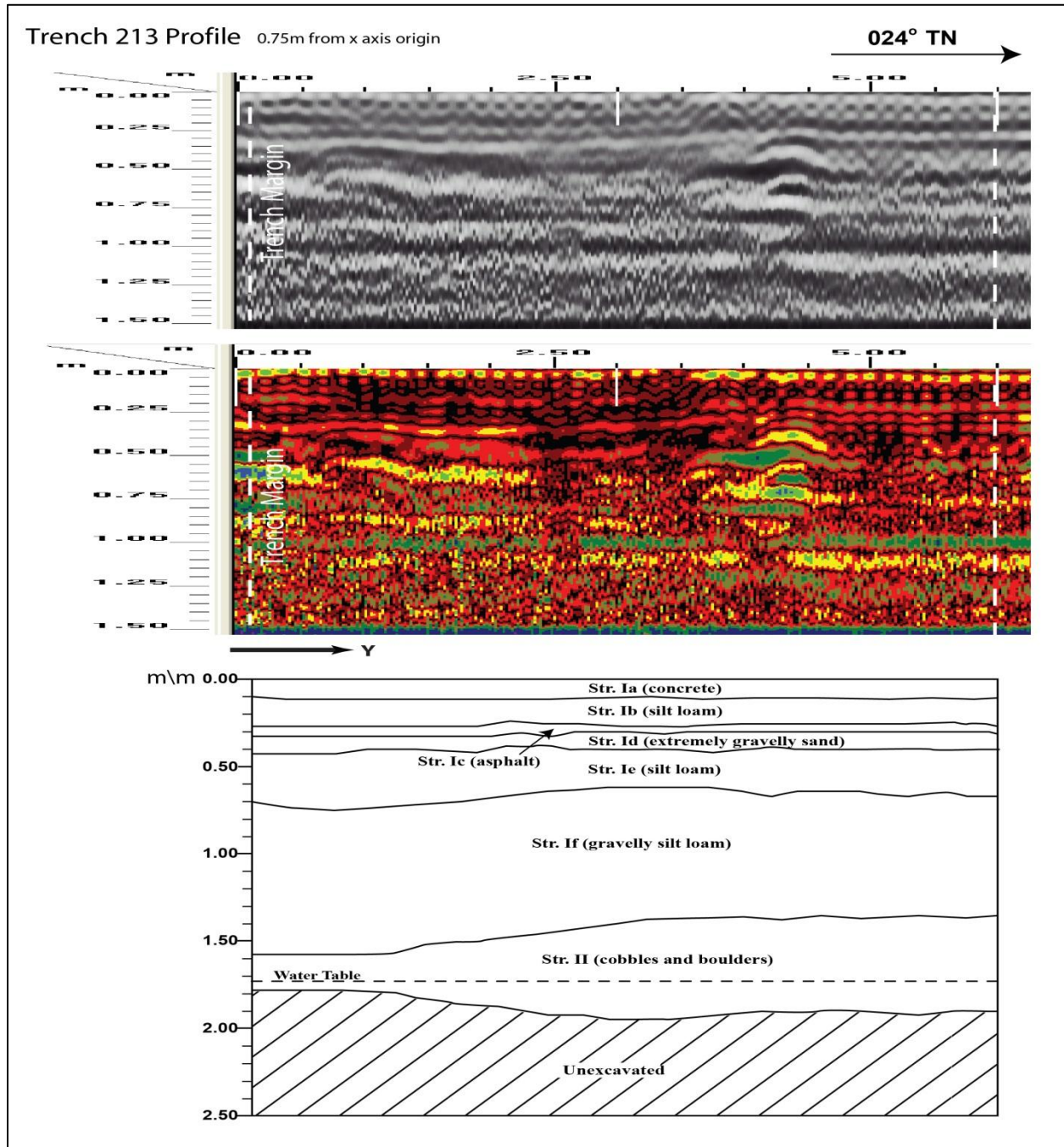


Figure 230. Visual comparison of excavated profile and GPR signal profile of T-213

Test Excavation 214

T-214 measured 0.8 m by 6.0 m and was oriented northwest to southeast and was located within a warehouse 75.0 m southeast of Kona Street and Kona Iki Street intersection, 9.5 m north of Kona Street. The GPR grid measured 3.0 m by 6.0 m with 50.0 cm spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: electrical line 8.7 m southwest. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs (Figure 231).

GPR depth profiles for T-214 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 232). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.2 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 0.75 mbs.

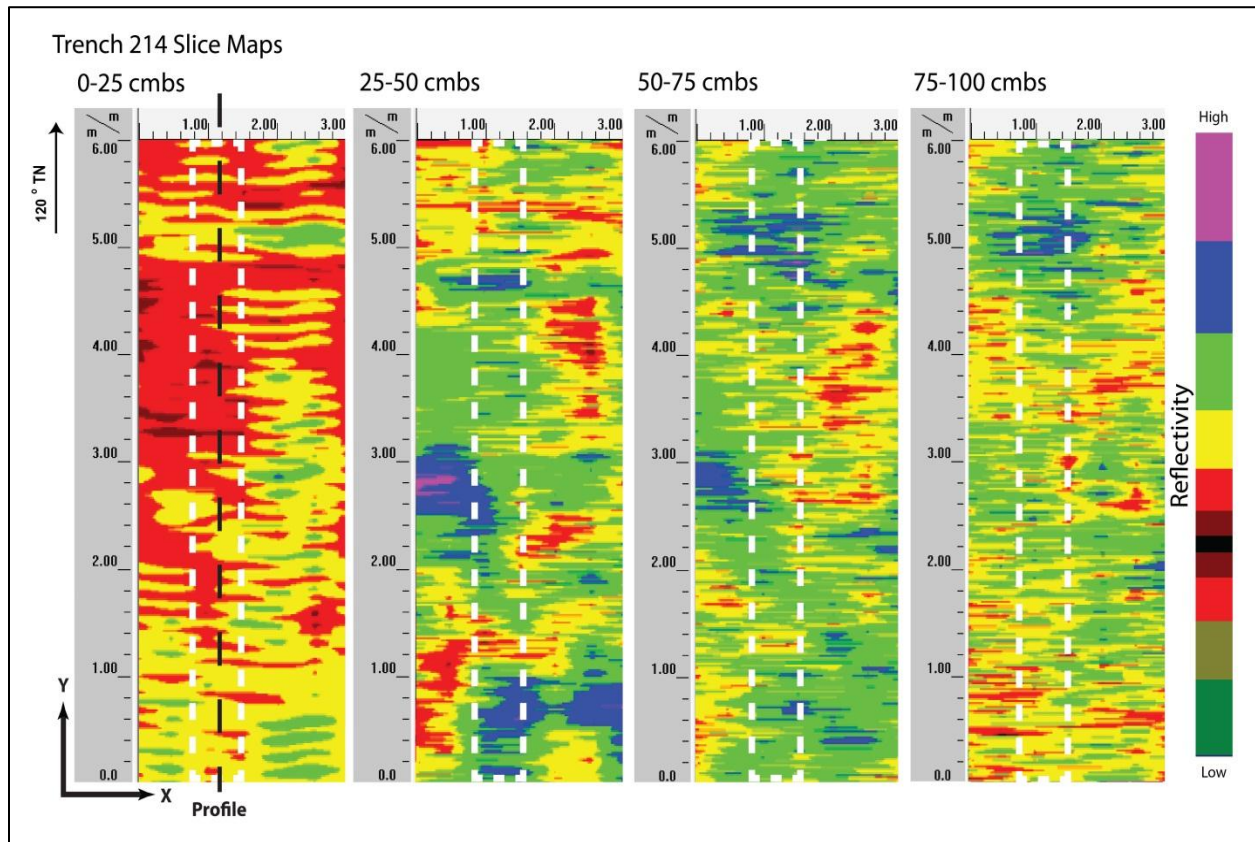


Figure 231. Slice maps of T-214 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 232). Strata Ia to Id were observed and occurred near the ground-truthed depths. Strata Ia through Id may be difficult to individually discern, possibly due to the fact that they were thin layers of compacted fill, but based on reflectivity and horizontal banding it was apparent that there were multiple layers of fill events. No discrete objects were observed in the GPR results or subsequent excavation.

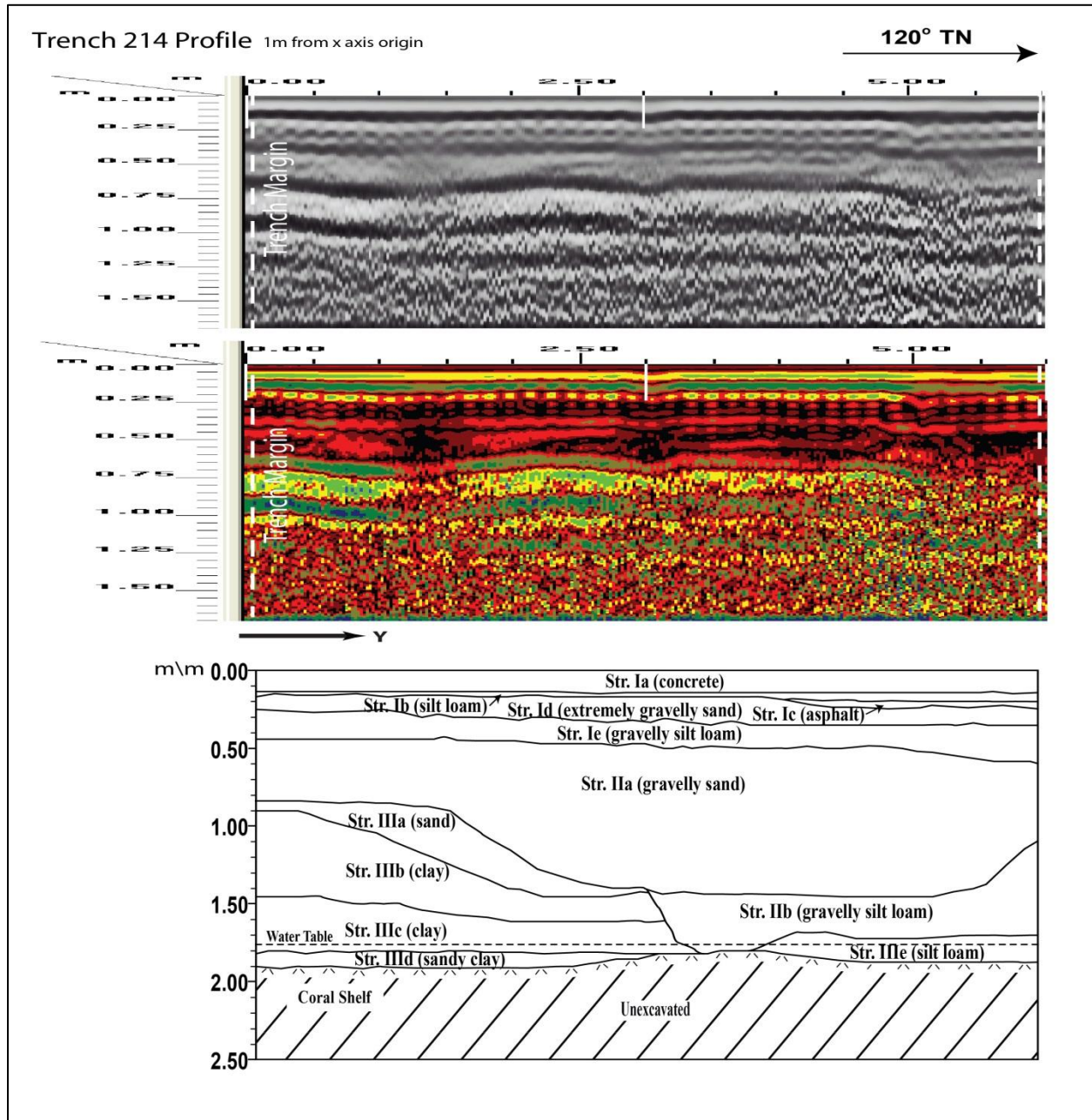


Figure 232. Visual comparison of excavated profile and GPR signal profile of T-214

Test Excavation 217

T-217 measured 0.9 m by 3.0 m and was oriented northwest to southeast and was located within the sidewalk on Kona Street, 100.0 m southeast of Kona Street and Kona Iki Street intersection. The GPR grid measured 2.0 m by 7.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water line 8.9 m southeast. A utility jacket or parking structure foundation column was encountered 0.62 mbs in the center of the excavation.

A review of amplitude slice maps indicated a linear feature but was not encountered but a utility was encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth except for the linear feature. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs and increases again around 0.75 mbs (Figure 233).

GPR depth profiles for T-217 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 234). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.15 mbs and again around 0.85 mbs. An anomaly was observed in the profile and may corresponded to the utility jacket that was encountered. The maximum depth of clean signal return was approximately 1.0 mbs.

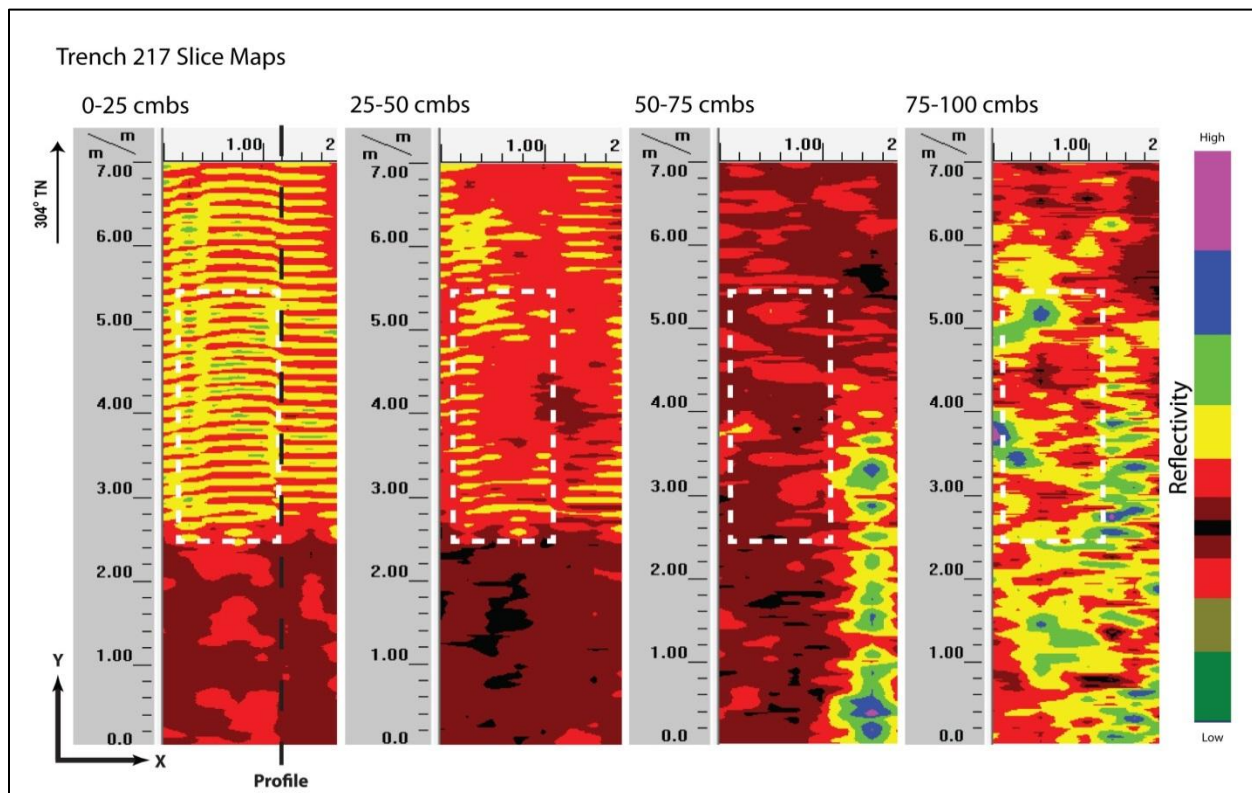


Figure 233. Slice maps of T-217 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 234). Strata Ia to Ic were clearly observed and occurred near the ground-truthed depths. Strata included a layer of concrete on top of sand fill, followed by sandy loam fill and then sandy silt loam and then a cobbly sand fill. A utility jacket was found 0.62 mbs. An anomaly was observed in the profile but does not occur at the same depth as the utility jacket. This could be a result of the wrong dielectric value being used. No other discrete objects or stratigraphic transitions were observed in the GPR results or subsequent excavation.

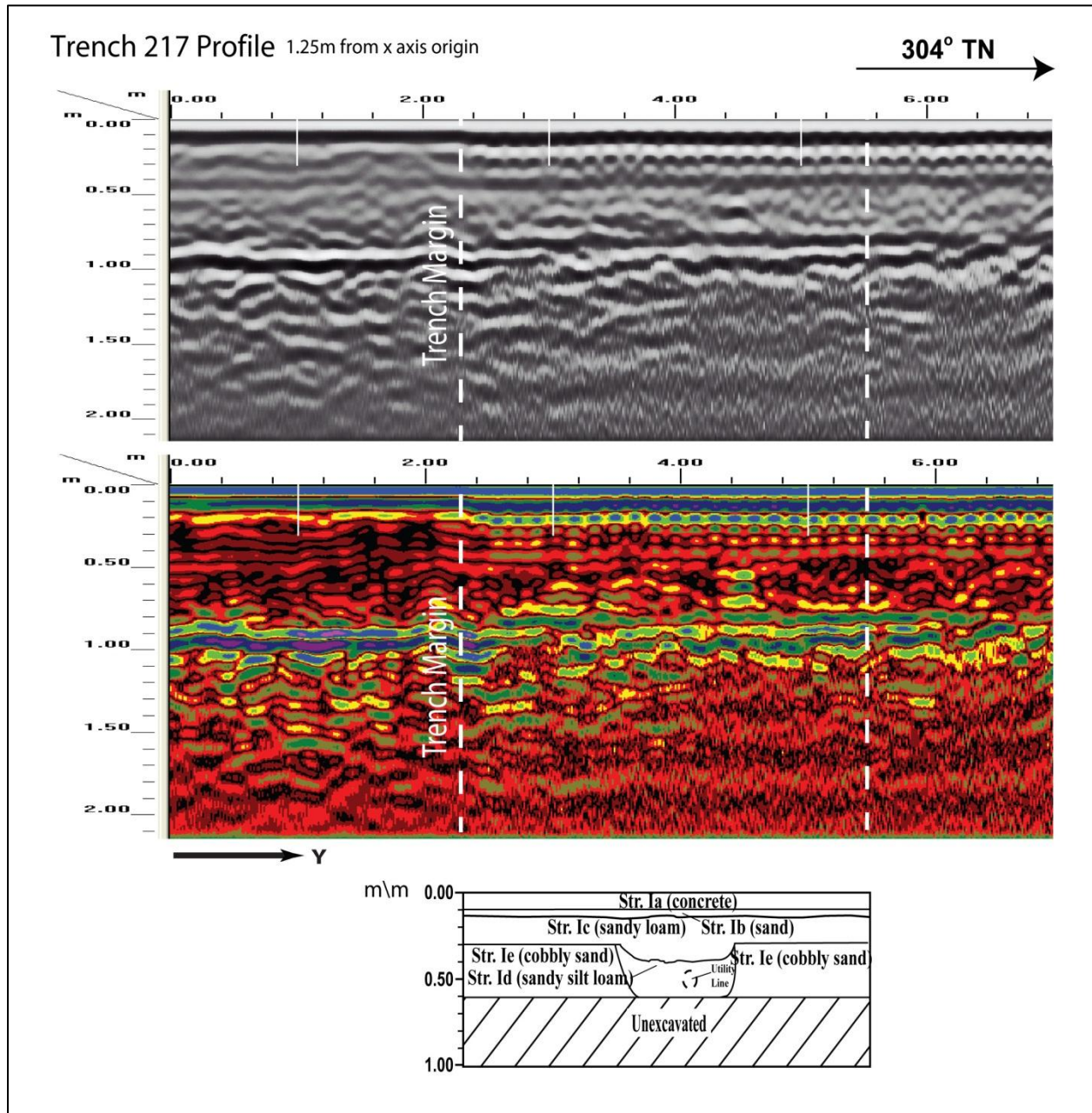


Figure 234. Visual comparison of excavated profile and GPR signal profile of T-217

Test Excavation 218

T-218 measured 0.9 m by 4.0 m and was oriented northwest to southeast and was located within the sidewalk on Kona Street, 70.0 m southwest of Kona Street and Keeaumoku Street intersection. The GPR grid measured 2.0 m by 6.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. According to PB CADD, there were no utilities within close proximity of the excavation. No utilities transected the excavation location.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.75 mbs (Figure 235).

GPR depth profiles for T-218 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 236). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.4 mbs. No utilities observed in the profile. The maximum depth of clean signal return was approximately 1.15 mbs.

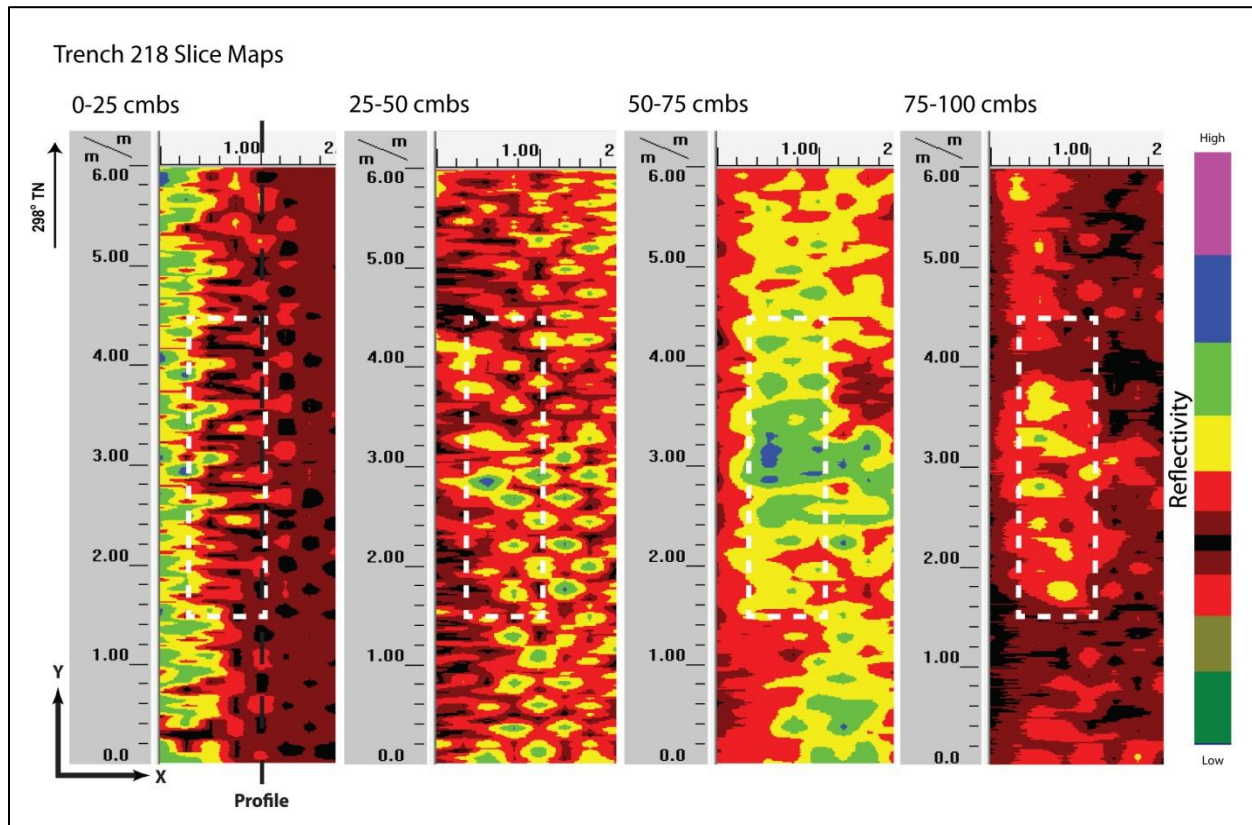


Figure 235. Slice maps of T-218 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 236). Strata Ia to If were all clearly observed and occurred at the ground-truthed depths. All other sediment transitions were below the maximum clean signal return depth. No discrete objects were observed in the GPR results or subsequent excavation.

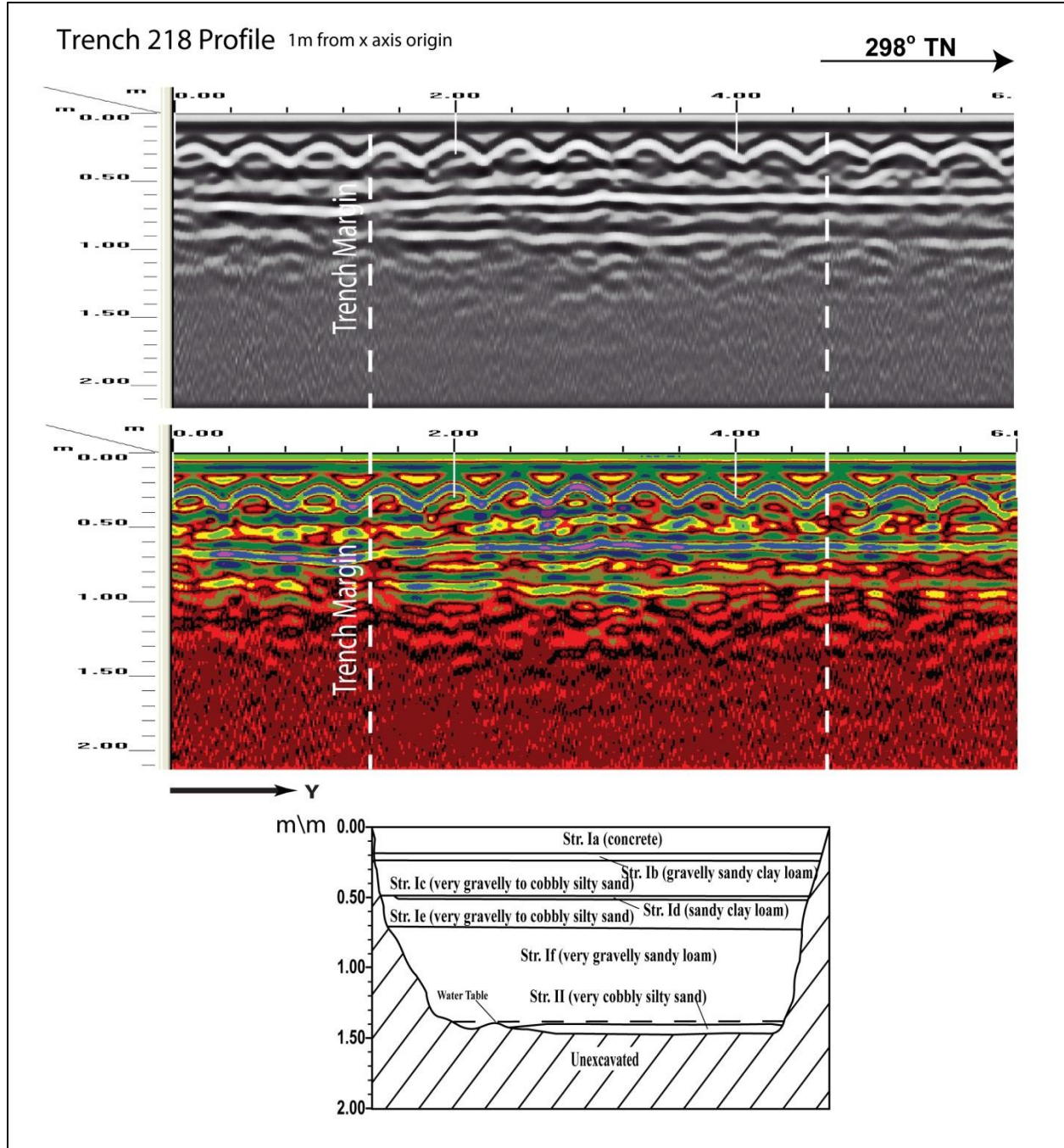


Figure 236. Visual comparison of excavated profile and GPR signal profile of T-218

Test Excavation 219

T-219 measured 0.9 m by 3.0 m and was oriented northeast to southwest and was located within a parking lot, 65.0 m northwest of Kona Street and Keeaumoku Street intersection. The GPR grid measured 2.5 m by 6.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: electrical line 1.0 m southwest. A PVC utility was encountered at 0.61 mbs in the south end of the excavation.

A review of amplitude slice maps indicated a linear feature but not within excavation boundaries but a utility was encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 237).

GPR depth profiles for T-219 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 238). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.35 mbs. Anomalies were observed in the profile and one corresponded to the utility encountered during excavation and the other was not within excavation boundaries. The maximum depth of clean signal return was approximately 0.75 mbs.

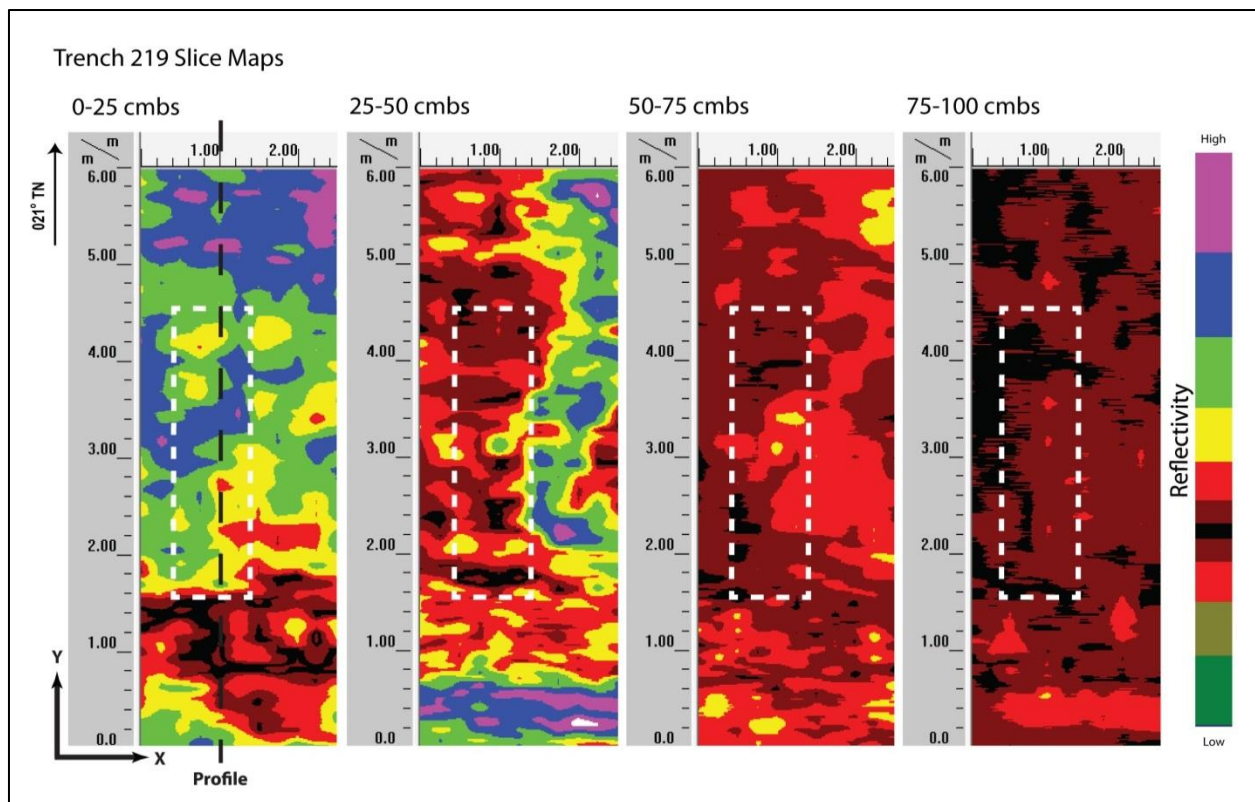


Figure 237. Slice maps of T-219 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 238). Strata Ia to Ic were clearly observed but do not occurred near the ground-truthed depths. All other sediment transitions were below the maximum clean signal return depth. A utility pipe was found 0.61 mbs. This corresponded to a hyperbola anomaly observed in the profile in the same location. No other discrete objects were observed in the GPR results or subsequent excavation.

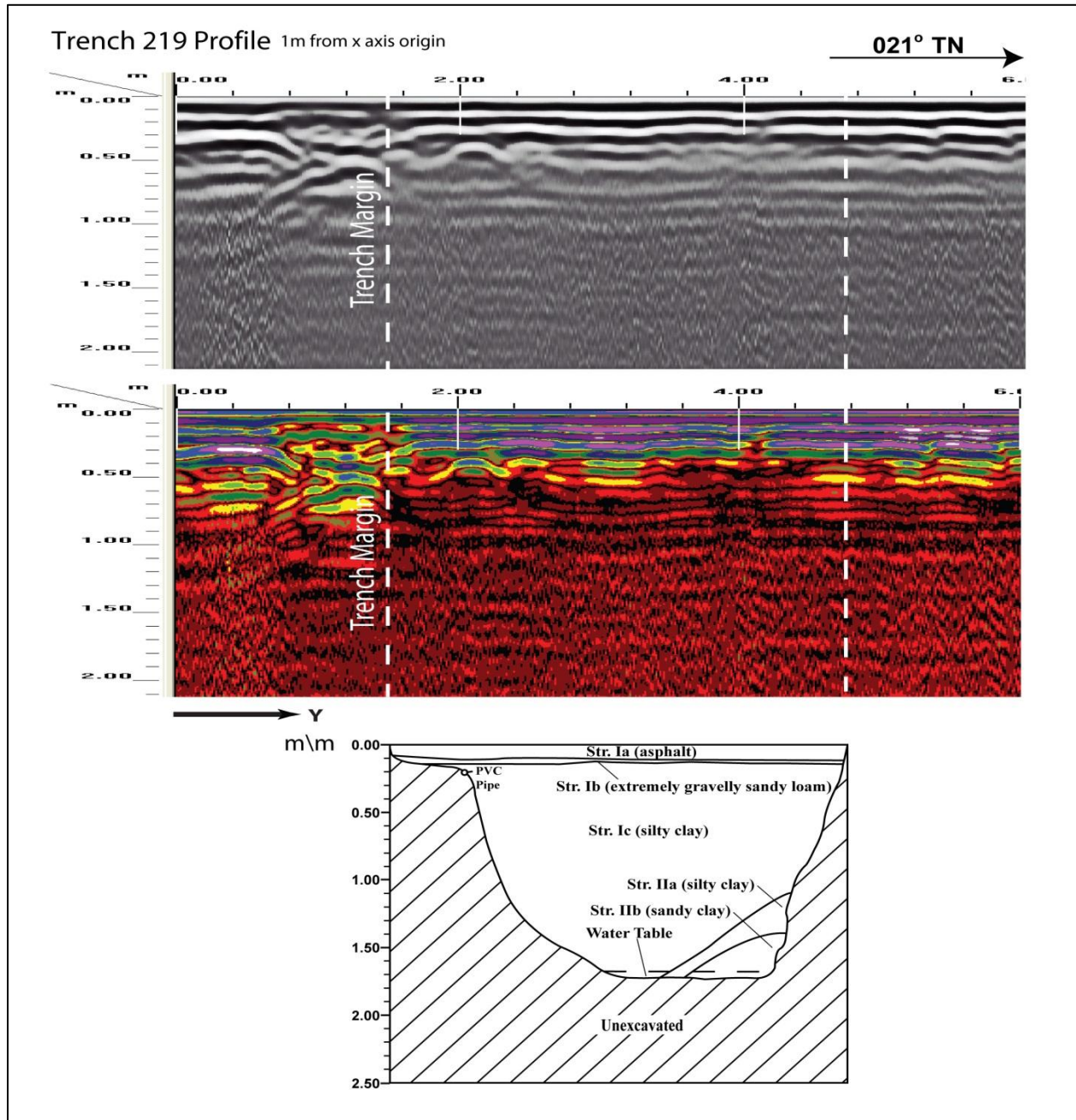


Figure 238. Visual comparison of excavated profile and GPR signal profile of T-219

Test Excavation 220

T-220 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the sidewalk on Kona Street, 35.0 m southeast of Kona Street and Kona Iki Street intersection. The GPR grid measured 2.0 m by 9.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. According to PB CADD, there were no utilities located within close proximity of the excavation. No utilities transected the excavation location.

A review of amplitude slice maps indicated a linear feature but it was not encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.75 mbs (Figure 239).

GPR depth profiles for T-220 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 240). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.65 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 0.8 mbs.

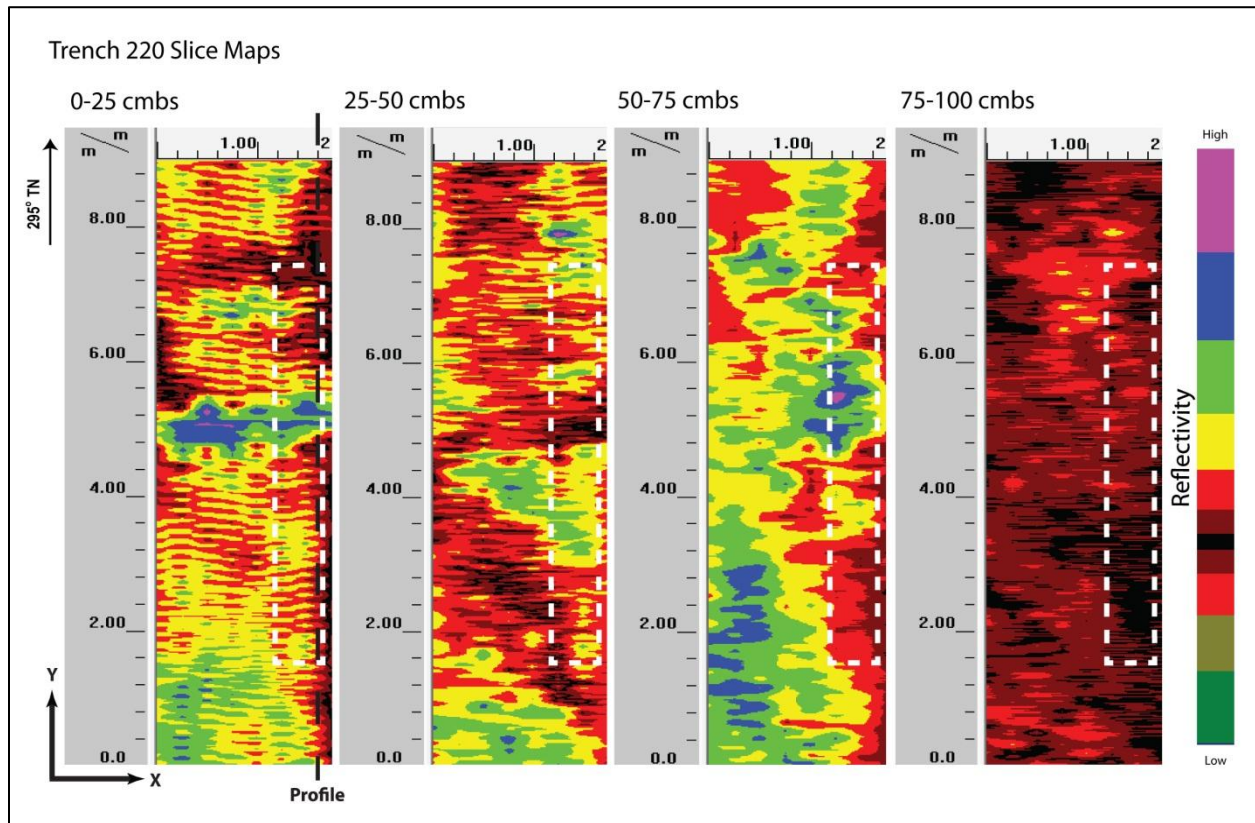


Figure 239. Slice maps of T-220 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 240). Strata Ia to Ie were clearly observed and occurred near the ground-truthed depths. Stratum If is difficult to individually discern due to the fact that the layer is less than 0.05 m thick. The disturbed filled pit (Stratum Ib) was also not observed in the profile. All other sediment transitions were below the maximum clean signal return depth. No discrete objects were observed in the GPR results or subsequent excavation.

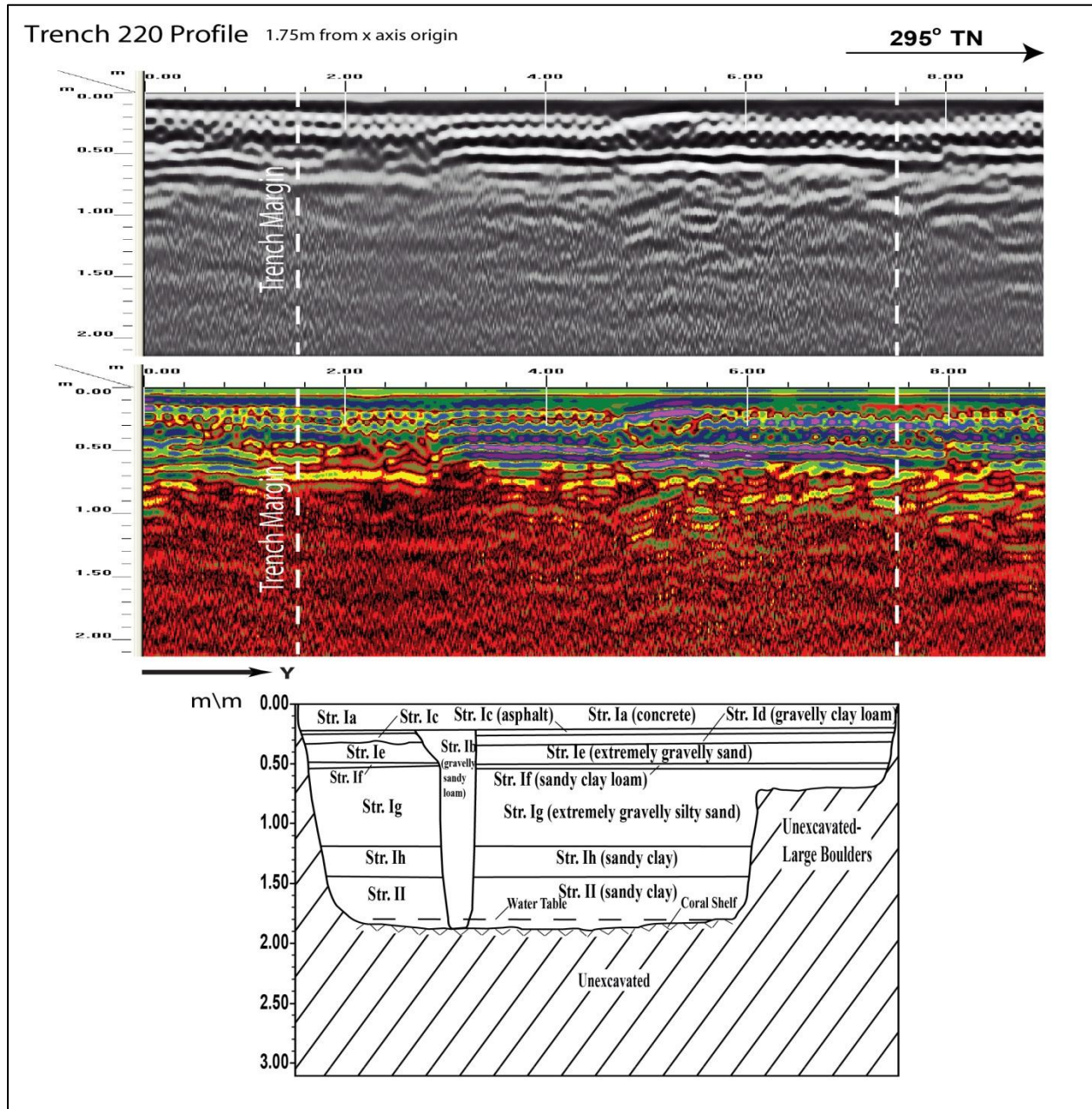


Figure 240. Visual comparison of excavated profile and GPR signal profile of T-220

Test Excavation 221

T- 221 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Kona Street, 31.0 m east of Kona Street and Kona Iki Street intersection. The GPR grid measured 3.0 m by 9.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water line 1.4 m southwest and 1.7 m southeast, electrical line 1.6 m northeast. A utility jacket/building foundation was encountered approximately 0.25 mbs along the north wall on the west end of the excavation.

A review of amplitude slice maps indicated a linear feature which coincides with a possible utility jacket observed during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth except the linear features. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.75 mbs (Figure 241).

GPR depth profiles for T-221 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 242). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.3 mbs. No anomalies were observed in the profile although a utility jacket was observed during excavation. The maximum depth of clean signal return was approximately 1.0 mbs.

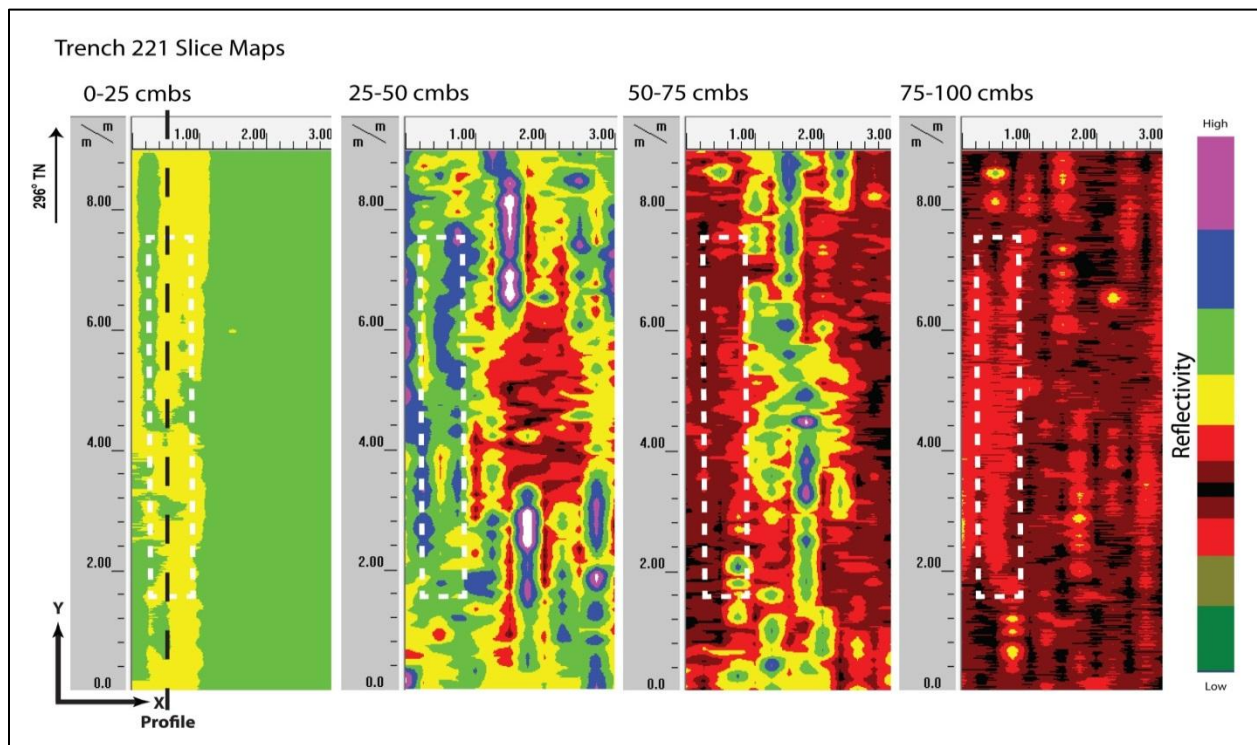


Figure 241. Slice maps of T-221 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 242). Strata Ia to Ic were clearly observed and occurred at the ground-truthed depths. Stratum Ib was difficult to discern due to how it was situated between the other strata and because it was less than 0.1 m thick. All other sediment transitions were below the maximum clean signal return depth. A concrete jacket was found 0.25 mbs. This jacket did not show up on the profile. This may be due to the fact that it was not reinforced with steel (rebar) or that it may have had a similar density to the surrounding stratum. No other discrete objects were observed in the GPR results or subsequent excavation.

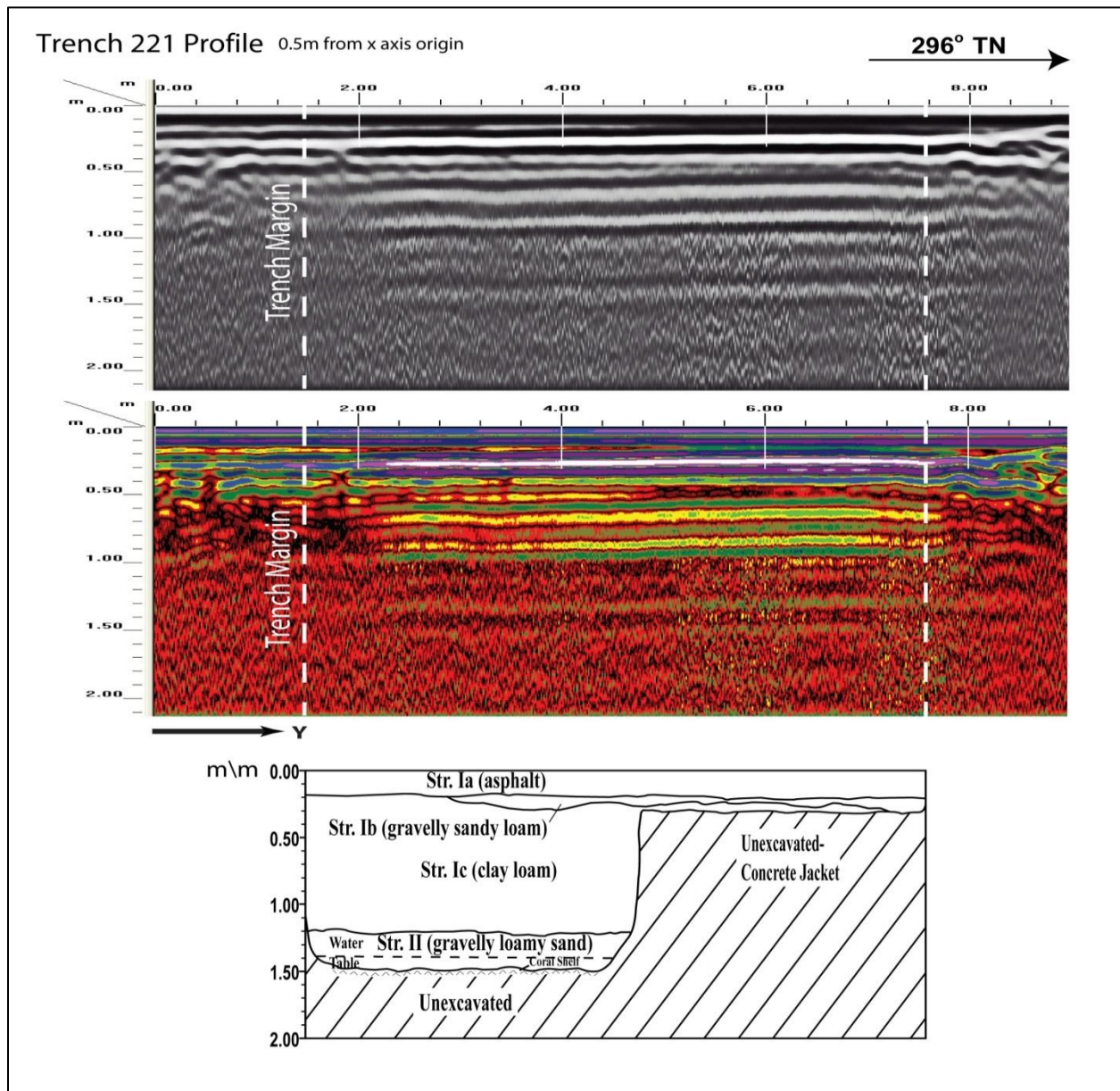


Figure 242. Visual comparison of excavated profile and GPR signal profile of T-221

Test Excavation 222

T-222 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Kona Street, 60.0 m southeast of Kona Street and Kona Iki Street intersection. The GPR grid measured 2.5 m by 9.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: electrical line 1.5 m northeast and 1.5 m southeast, water line 1.4 m southwest. A broken utility pipe was encountered 0.5 mbs in the east end of the excavation.

A review of amplitude slice maps indicated no linear features although a utility pipe was encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 243).

GPR depth profiles for T-222 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 244). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.3 mbs. No utilities were observed in the profile although a utility was encountered during excavation. The maximum depth of clean signal return was approximately 1.0 mbs.

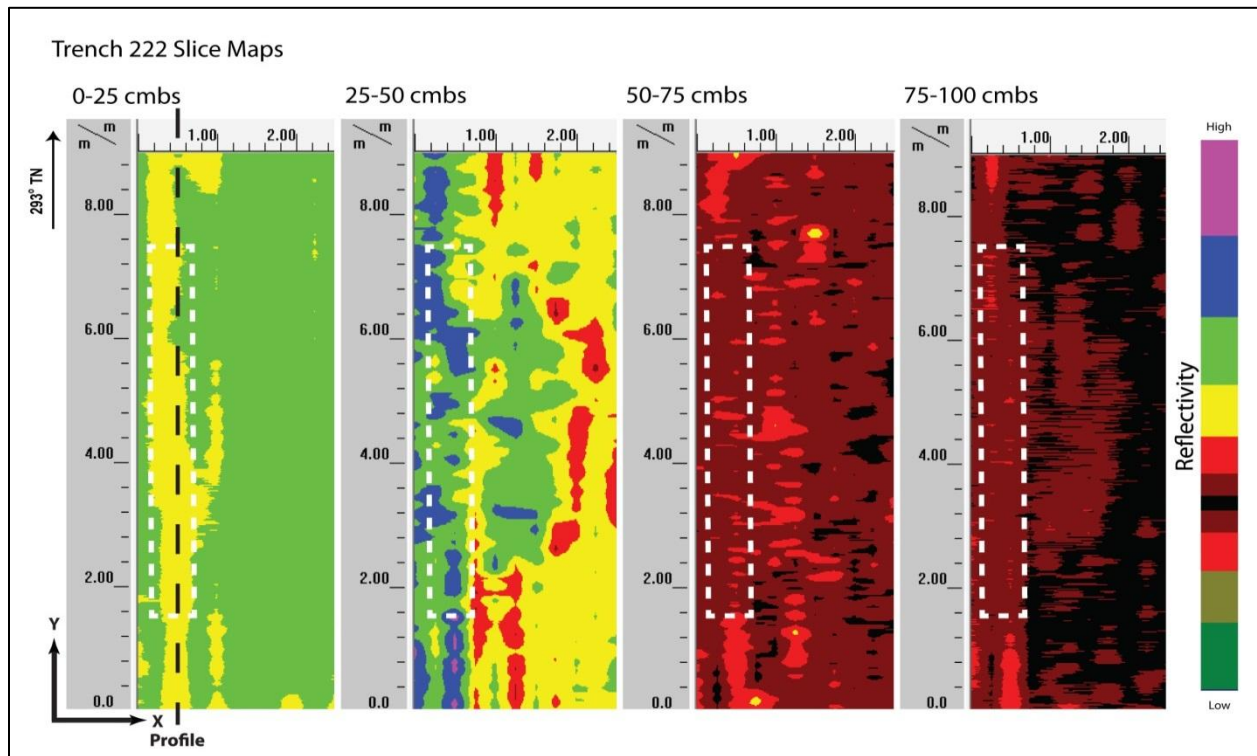


Figure 243. Slice maps of T-222 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 244). Strata Ia and Ib were clearly observed and occurred at the ground-truthed depths. A utility pipe was found 0.5 mbs. This pipe did not show up on the profile or slice maps. This may be due to the fact that the pipe was empty and broken or because it was small in diam. No other discrete objects were observed in the GPR results or subsequent excavation.

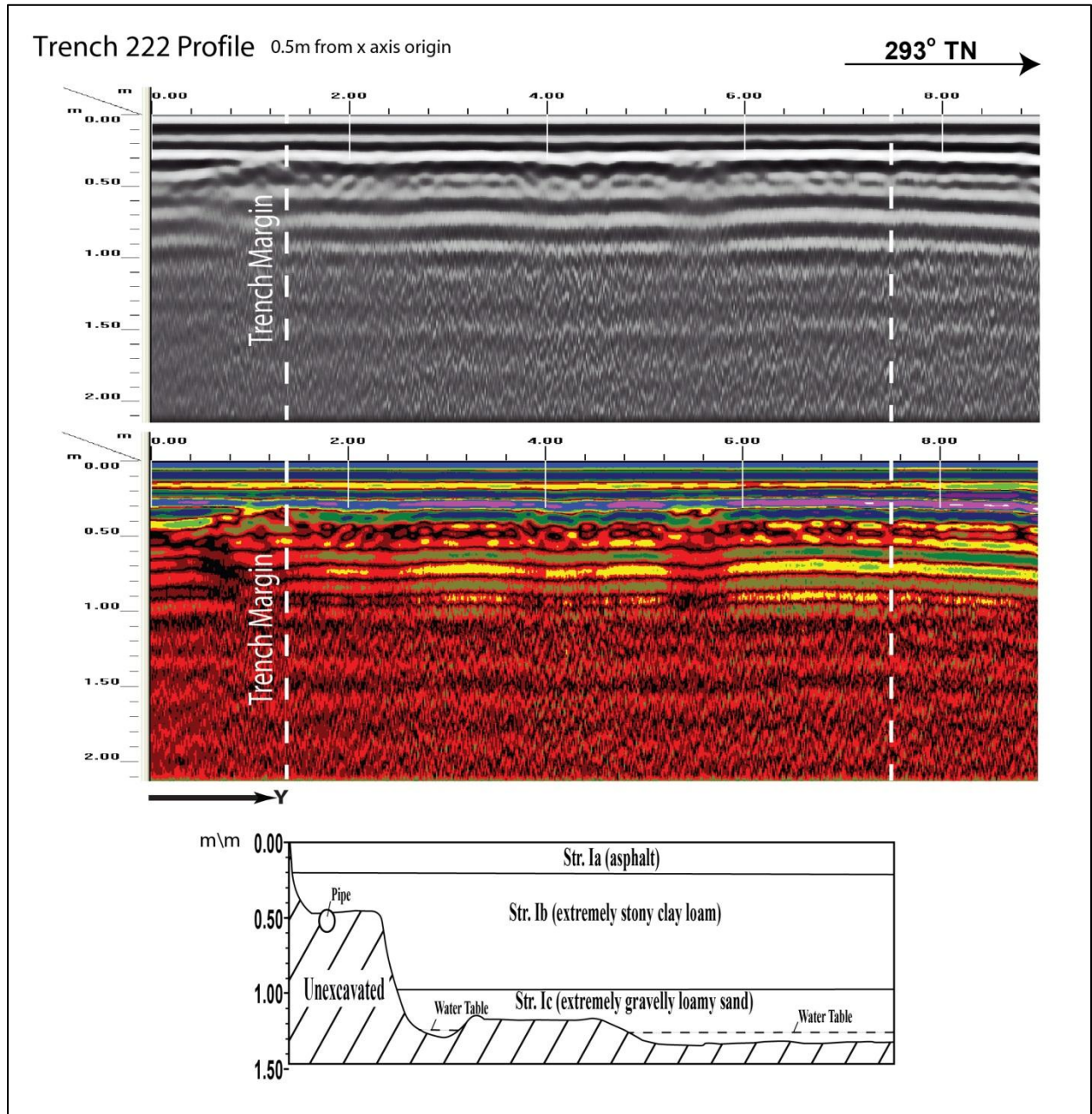


Figure 244. Visual comparison of excavated profile and GPR signal profile of T-222

Section 5 Kaka'ako Makai Geographic Zone (T-226 to T-232A)

5.1 Overall Location

For reporting purposes for this AIS, the City Center Section 4 of the HHCTCP has been divided into 11 zones based on geographical and cultural boundaries. The Kaka'ako Makai Geographic Zone was located within the central portion of Honolulu Ahupua'a, Honolulu District, Island of O'ahu, in a physiographic division known as the Honolulu Plain (Armstrong 1983:36). The Kaka'ako Makai portion of the City Center Section 4 was an additional utility re-location route that extends approximately 1,250 m forming a *makai* loop off of the main transit alignment (Figure 245). Where the main transit line heads off onto Halekauwila Street approximately 100 m southeast of the Downtown Station, the utility relocation route continues to head south on Nimitz Highway. The utility relocation route makes a sharp turn heading *mauka* (northeast) off of Nimitz Highway onto Punchbowl Street and then turns southeast on Pohukaina Street running parallel and one block *makai* of the main transit route on Halekauwila Street. The utility re-location route then reconnects with the transit alignment by turning *mauka* (northeast) on Cooke Street to rejoin the main transit alignment at the intersection of Halekauwila and Cooke Streets.

A total of 16 test excavations (T-226 through T-232, T-226A, T-226B, T-226C, T-226D, T-227A, T-228A, T-228B, T-231A, and T-232A) were excavated in the Kaka'ako Makai Zone along and adjacent to Punchbowl, Pohukaina, and Cooke Streets. Test excavation numbering generally progresses from northwest to southeast. The density of testing in this zone was less because confidence was high that the northwest portion of the Zone (northwest of Punchbowl Street) was off-shore shallows into the mid-1800s.

All of these Kaka'ako Makai test excavations were within City and County of Honolulu road right-of-ways. Seven of the test excavations (T-226, T-226A, T-226B, T-226C, T-226 D, T-227, and T-227A) were along Punchbowl Street within TMK [1] 2-1-027; seven test excavations (T-227B, T-228, T-228A, T-229, T-230, T-231, and T-231A) were along Pohukaina Street within TMK [1] 2-1-030, [1] 2-1-051, and [1] 2-1-054; and two (T-232 and T-232A) were along Cooke Street within TMK [1] 2-1-052.

5.2 Geography, Geology, and Land Forms

The northwest portion of the Kaka'ako Makai Zone was believed to have been coastal shallows into the mid-1800s (see Vol. II Figure 24). The most inland portion (where Cooke Street connects with Halekauwila Street would have been approximately 400 m inland of the natural coastline. Present day elevations in the zone range from approximately 1.4 to 1.9 m amsl. Portions of the project area were in fishponds.

The average annual rainfall measures approximately 658 to 698 mm (26 to 28 inches) (Giambelluca et al. 2011), which would be marginal at best for non-irrigated agriculture. Nu'uuanu Stream approximately 900 m to the northwest would have been a major source of fresh water. The Kaka'ako area to the east was known for its springs.

The Kaka'ako Makai Zone consists of a portion of the broad elevated coral reef in southern Oahu that probably formed during the 7.5-m (Waimanalo) stand (Macdonald et al. 1983:420-

421). Most of the Kaka'ako Makai Zone was in the shallows of, or just inshore of the main natural entrance channel to Honolulu Harbor. The landscape would have been dominated by the bay formed by Pākākā Point (with Kuloloia Beach) on the north side and Kaholoakeāhole point on the south side. The deep channel and bay would probably have been a focus of fishermen for centuries. Pākākā Point was a logical choice for the construction of the Honolulu Fort that would dominate the waterfront for decades.

Vegetation in this area was not well documented, but just prior to development in the early twentieth century was understood as including *naupaka* (*Scaevola taccada*), *keawe* (*Prosopis pallida*), and coconut (*Cocos nucifera*). Present vegetation was almost entirely the result of landscaping efforts.

According to the U.S. Department of Agriculture Soil Survey Geographic (SSURGO) Database (2001) and soil survey data gathered by Foote et al. (1972), soils within the Kaka'ako Makai Zone consist predominantly of Fill Land (FL), with an area of 'Ewa Silty Clay Loam (EmA) in the central portion of the zone (Figure 245). Fill Land soils were described as:

...areas filled with material dredged from the ocean or hauled from nearby areas, garbage, and general material from other sources... This land type was used for urban development including airports, housing areas, and industrial facilities [Foote et al. 1972:31].

'Ewa Silty Clay Loam soils were described as:

...well-drained soils in basins and on alluvial fans... [that] developed in alluvium derived from basic igneous rock... These soils were used for sugarcane, truck crops, and pasture. The natural vegetation consists of fingergrass, kiawe, koa haole, klu, and uhaloa [Foote et al. 1972:29].

5.3 Modern Land Use and Built Environment

The Kaka'ako Makai Zone traverses an urban environment through the neighborhood of Kaka'ako. The Kaka'ako Makai Zone corridor begins at the intersection of South Nimitz Highway and Richards Street at the northwest end, follows along South Nimitz Highway onto Ala Moana Boulevard, where it continues until Punchbowl Street, then follows Punchbowl Street to Pohukaina Street, follows Pohukaina Street until Cook Street, then follows along Cook Street until Halekauwila Street at the southeast end. Parcels bordering the Kaka'ako Makai Zone corridor contain commercial buildings and warehouses, high-rise condominiums, and large parking lots. A massive utility corridor was also present throughout the Kaka'ako Makai Zone containing electrical, gas, water, sewer, and storm lines. The number and distribution of these existing utilities indicate that this portion of the transit corridor has been heavily disturbed in the past.

5.4 GPR Sediment Summary

Test excavations in the Kaka'ako Makai Geographic Zone (Zone 11) revealed that the area was predominantly Fill Lands (FL) as predicted by the U.S.G.S Soil survey map of the zone (Figure 245). Naturally deposited sediments encountered in this zone were generally too deep for the GPR to clearly read. The average depth of clean signal return for this area was approximately one m. Test Excavations that contained naturally deposited sediments within the GPR clean signal range were included in Table 4. Naturally deposited sediments within the range of clean GPR signal return for Zone 11. Representative signal texture profiles for Zone 11 are shown in Figure 246. Signal texture profiles were only collected if the signal return was clear and the stratum was at least 0.25 m thick.

Table 4. Naturally deposited sediments within the range of clean GPR signal return for Zone 11

ZONE 11- KAKAAKO MAKAI (T-226-T-232A)			
<u>TEST EXCAVATION</u>	<u>STRATUM</u>	<u>MATERIAL</u>	<u>STRATUM ORIGIN (mbs)</u>
226A	IIA	loamy sand	0.35
226B	II	sandy loam	0.45
227	II	silty sand	0.5
227B	II	silty clay	1.1

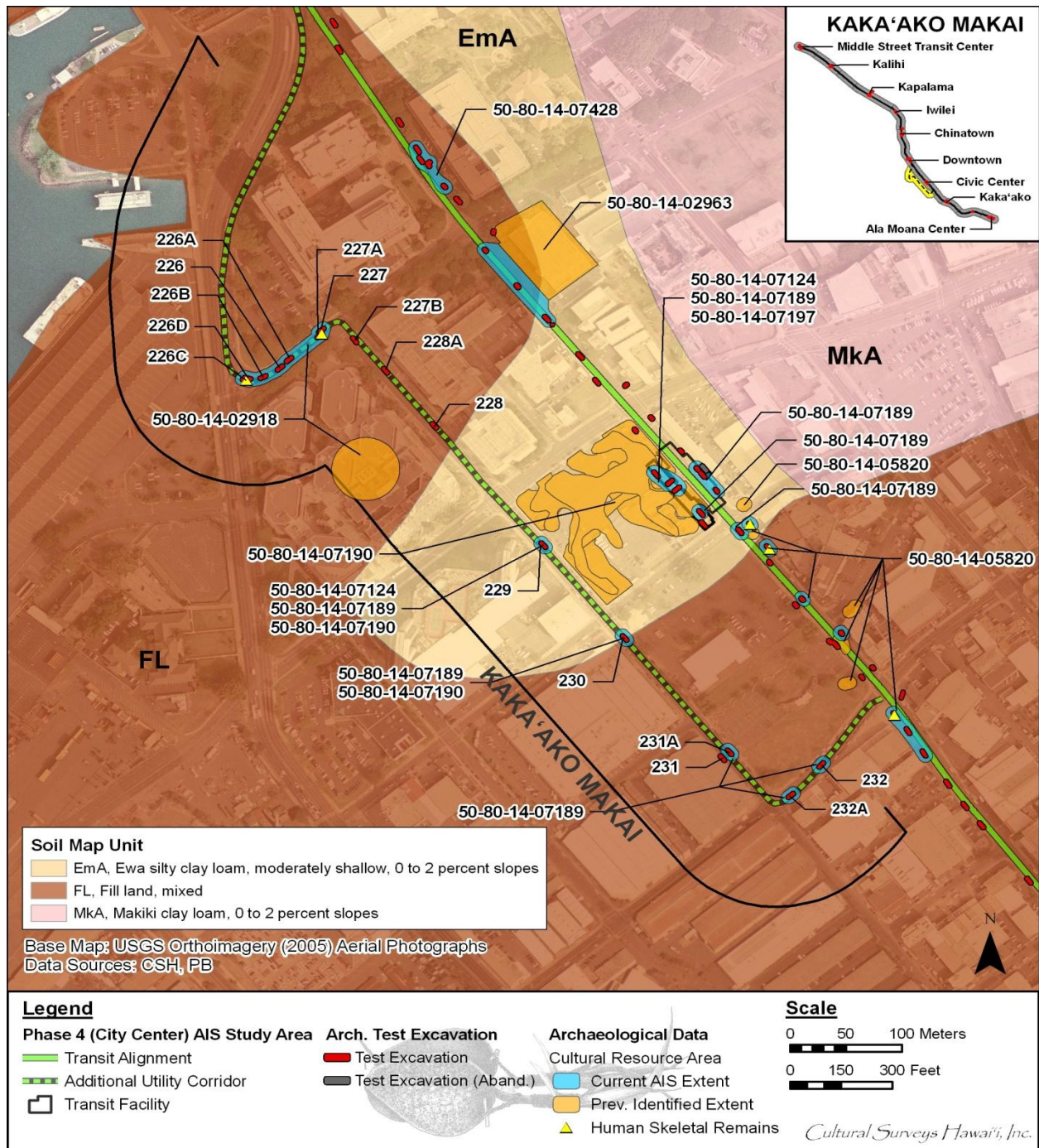


Figure 245. Aerial photograph (source: U.S. Geological Survey Orthoimagery 2005) with overlay of the Soil Survey of Hawai'i (Foote et al. 1972) showing sediment types within and in the vicinity of the Kaka'ako Makai Zone

Examples of GPR Signal Textures Representing Zone 11 Sediments

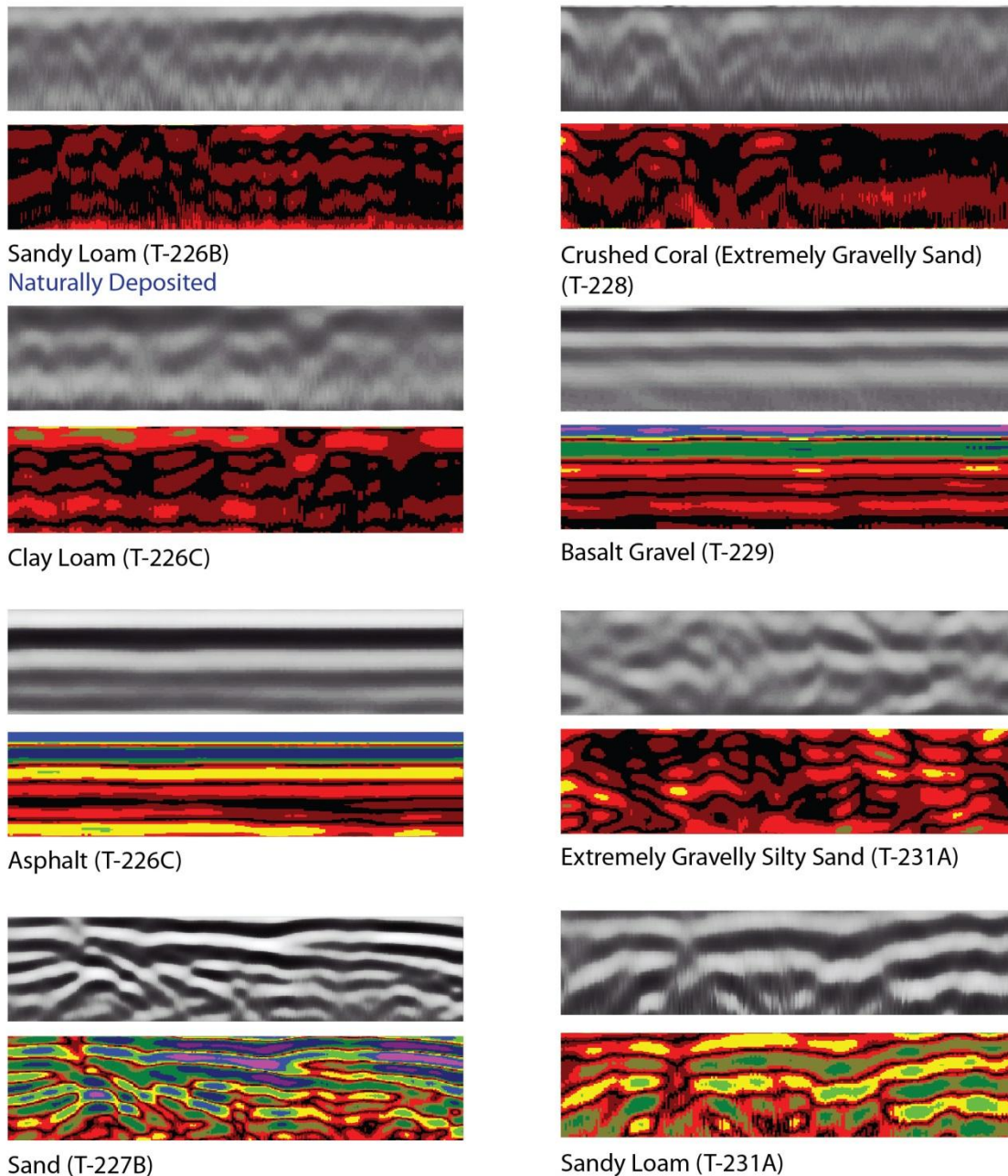


Figure 246. Examples of GPR signal textures representing Zone 11 sediments

Test Excavation 226

T-226 measured 0.6 m by 6.0 m and was oriented northeast to southwest and was located within the road cut of Punchbowl Street, 57.0 m northeast of Ala Moana Boulevard and Punchbowl Street intersection. The GPR grid measured 2.0 m by 9.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water drain 1.8 m southeast, water line 1.9 m northwest, sewer line 6.0 m east and southeast. Concrete jackets were encountered on the north and south end of excavation and a large utility pipe was encountered 0.6 mbs running through the center of the excavation location.

A review of amplitude slice maps indicated linear features which seem to corresponded to the utilities and concrete jackets encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 247).

GPR depth profiles for T-226 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 248). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.2 mbs. An anomaly was observed in the profile and corresponded with the large utility pipe encountered during excavation. The maximum depth of clean signal return was approximately 1.0 mbs.

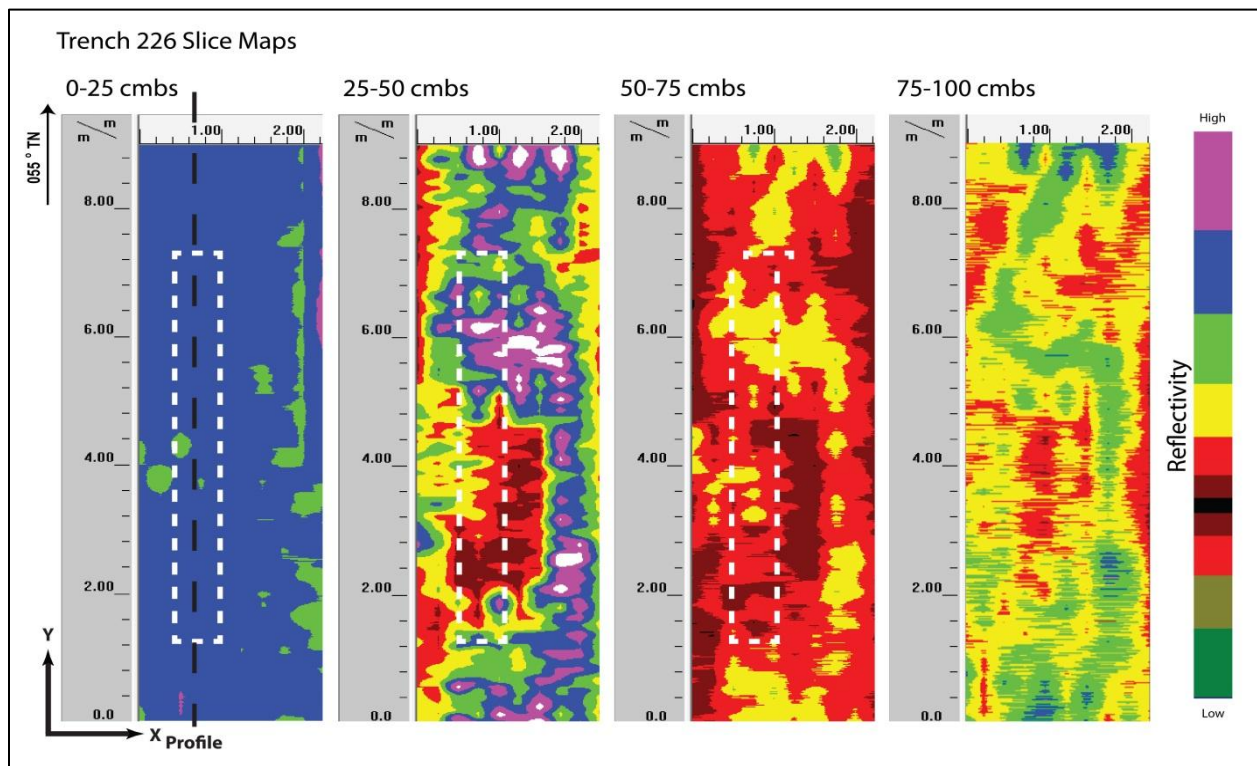


Figure 247. Slice maps of T-226 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 248). Strata Ia and Ic were clearly observed and occurred at the ground-truthed depths. Stratum Ib was not able to be observed in the profile due to the large anomaly. Two concrete jackets and a utility pipe were found 0.12 and 0.6 mbs, respectively. A large hyperbola anomaly was observed in the profile and corresponded to the location that the utility pipe was found during excavation. No other discrete objects or stratigraphic transitions were observed in the GPR results or subsequent excavation.

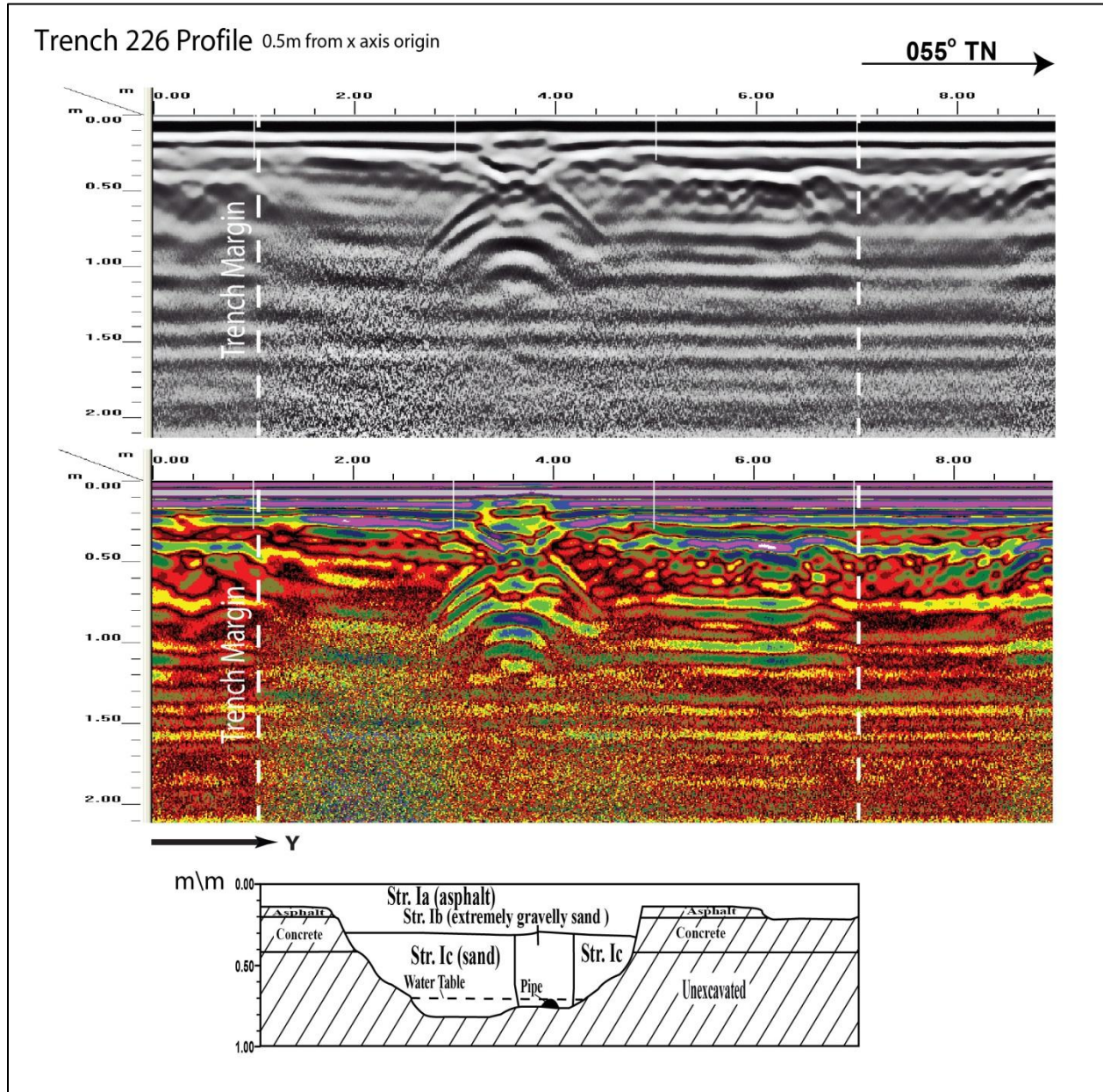


Figure 248. Visual comparison of excavated profile and GPR signal profile of T-226

Test Excavation 226A

T-226A measured 0.6 m by 6.0 m and was oriented northeast to southwest and was located within the road cut of Punchbowl Street, 52.0 m southwest of Punchbowl Street and Pohukaina Street intersection. The GPR grid measured 2.5 m by 10.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: sewer line 1.1 m southwest, water line 1.3 m northwest, water drain 2.8 m southeast. A utility pipe was encountered 0.55 mbs in the center of the excavation and a utility jacket along the entire edge of the northeast wall approximately 0.25 mbs.

A review of amplitude slice maps indicated a linear features that runs parallel to the excavation and could corresponded to the utility jacket encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 249).

GPR depth profiles for T-226A identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 250). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.2 mbs. Several anomalies were observed in the profile and one corresponded to the utility pipe encountered during excavation and the others were not within the excavation boundaries. The maximum depth of clean signal return was approximately 0.9 mbs.

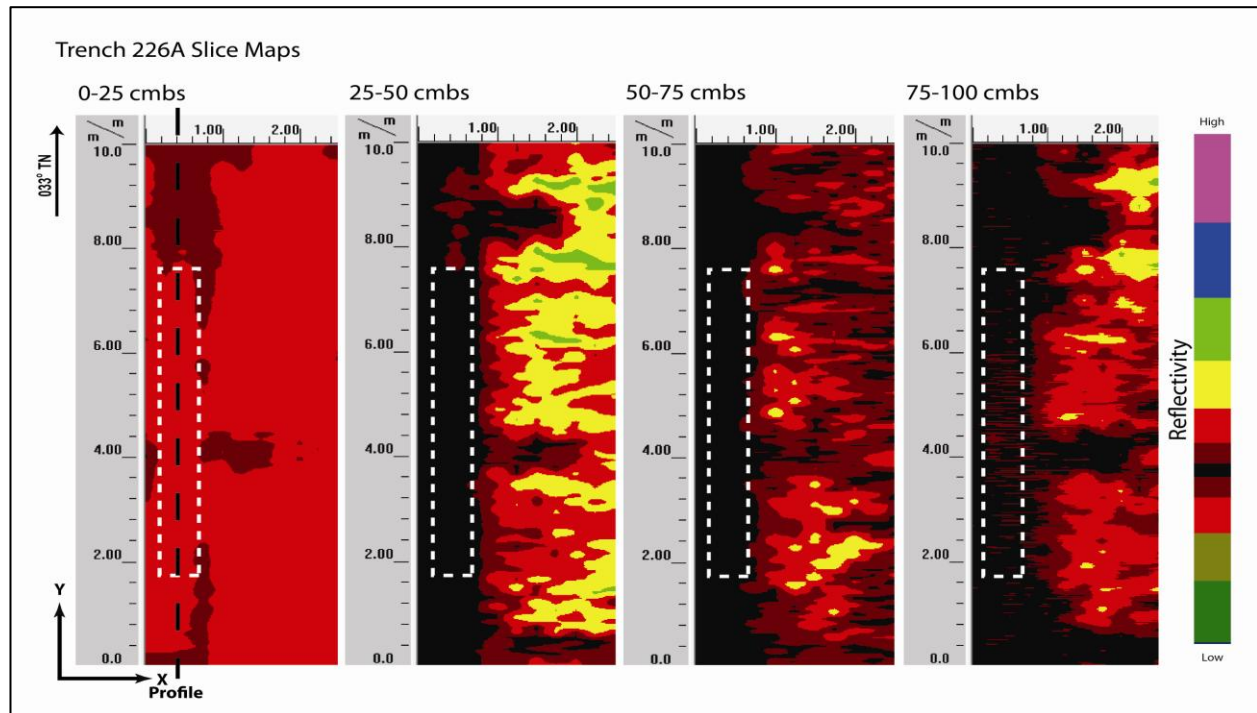


Figure 249. Slice maps of T- 226A at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 250). Strata Ia to Ic were clearly observed and occurred near the ground-truthed depths. An increase in reflectivity was observed around 0.8 mbs and may represent loamy sand or sand located at this depth. A pipe was found 0.55 mbs. A void was observed at the same location as the utility pipe. A utility jacket was found 0.25 mbs. This jacket did not show up on profile possibly due to the fact that the profile was not taken on the wall that the jacket was found along. No other discrete objects were observed in the GPR results or subsequent excavation.

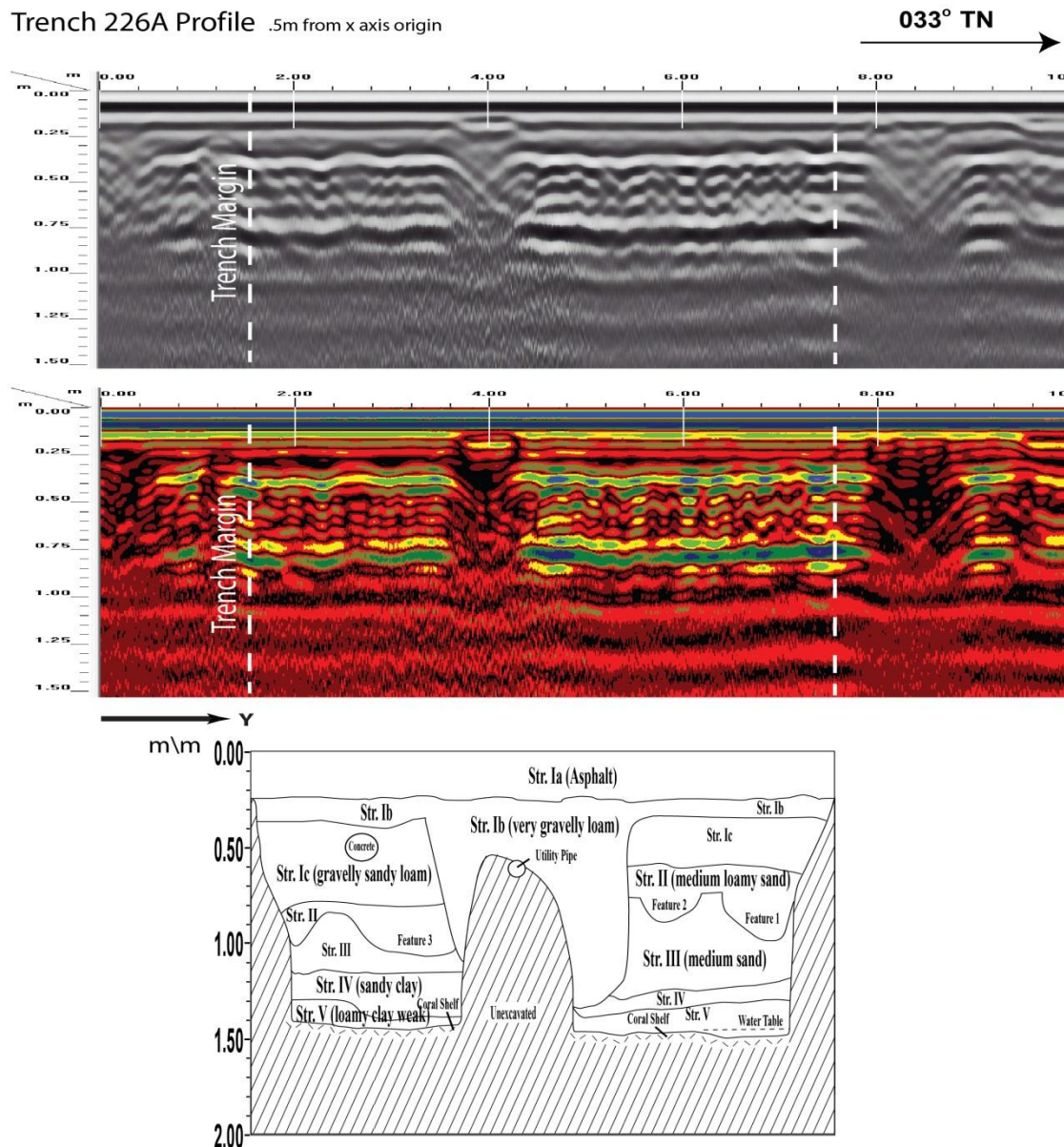


Figure 250. Visual comparison of excavated profile and GPR signal profile of T- 226A

Test Excavation 226B

T-226B measured 0.6 m by 6.0 m and was oriented northeast to southwest and was located within the road cut of Punchbowl Street, 20.0 m east of Ala Moana Boulevard and Punchbowl Street intersection. The GPR grid measured 3.0 m by 10.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water line 2.6 m southeast, water drain 3.8 m southeast, sewer line 6.8 m southeast. No utilities transected the excavation location.

A review of amplitude slice maps indicated linear but not within the excavation boundaries. Reflectivity was relatively uniform throughout the grid and decreased with depth except for the linear features. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs (Figure 251).

GPR depth profiles for T-226B identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 252). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.2 mbs. Anomalies were observed in the profile but not within excavation boundaries. The maximum depth of clean signal return was approximately 0.75 mbs.

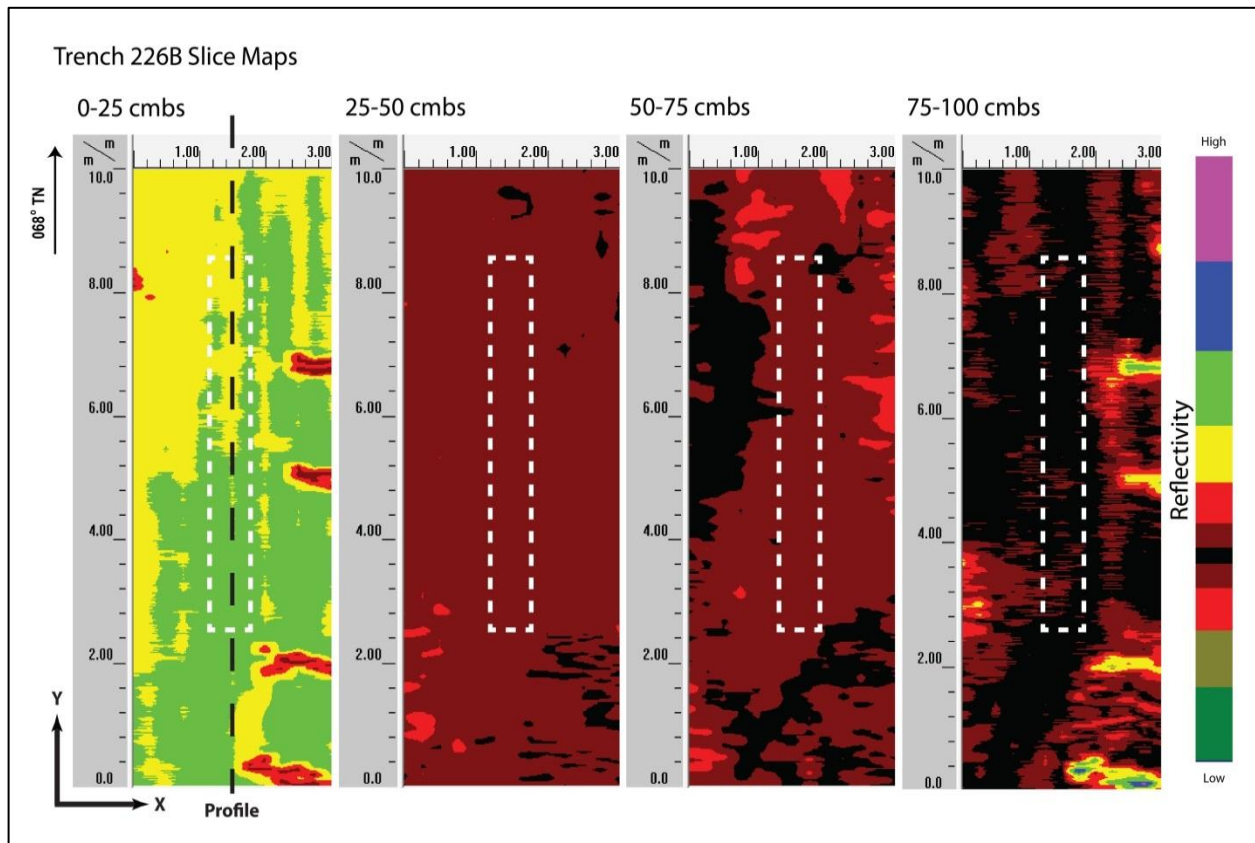


Figure 251. Slice maps of T-226B at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 252). Strata Ia through II were clearly observed and occurred at the ground-truthed depths. Textural changes in the form of multiple small hyperbolas were apparent in Stratum II which was a natural sandy loam. All other sediment transitions were below the maximum clean signal return depth. No discrete objects were observed in the GPR results or subsequent excavation.

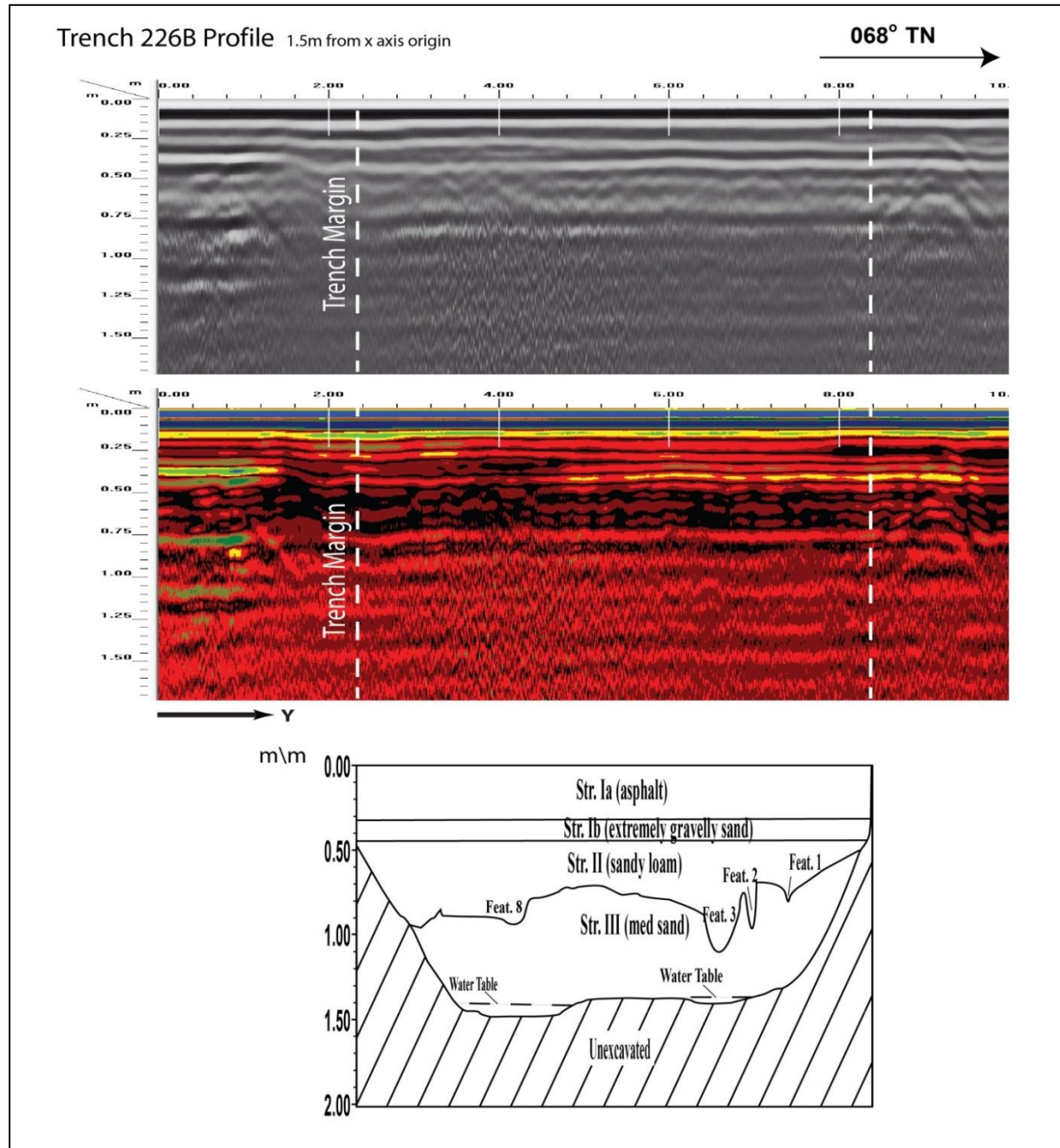


Figure 252. Visual comparison of excavated profile and GPR signal profile of T-226B

Test Excavation 226C

T-226C measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Punchbowl Street, 25.0 m northeast of Ala Moana Boulevard and Punchbowl Street intersection. The GPR grid measured 3.0 m by 10.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: cable line 1.5 m west. Utility lines were encountered 0.36 mbs on the southwest corner and an isolated human skeletal remain was encountered 1.15 mbs in the south wall of the excavation.

A review of amplitude slice maps indicated some linear features in the east side of the excavation but utility lines were observed in the west side. Reflectivity was relatively uniform throughout the grid and decreased with depth except for the linear feature. A transition from higher reflectivity to lower reflectivity was observed at approximately 25 mbs (Figure 253).

GPR depth profiles for T-226C identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 254). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.15 mbs. Several anomalies were observed on the profile but were not encountered during excavation and did not correspond to the utilities that were encountered. The maximum depth of clean signal return was approximately 0.75 mbs.

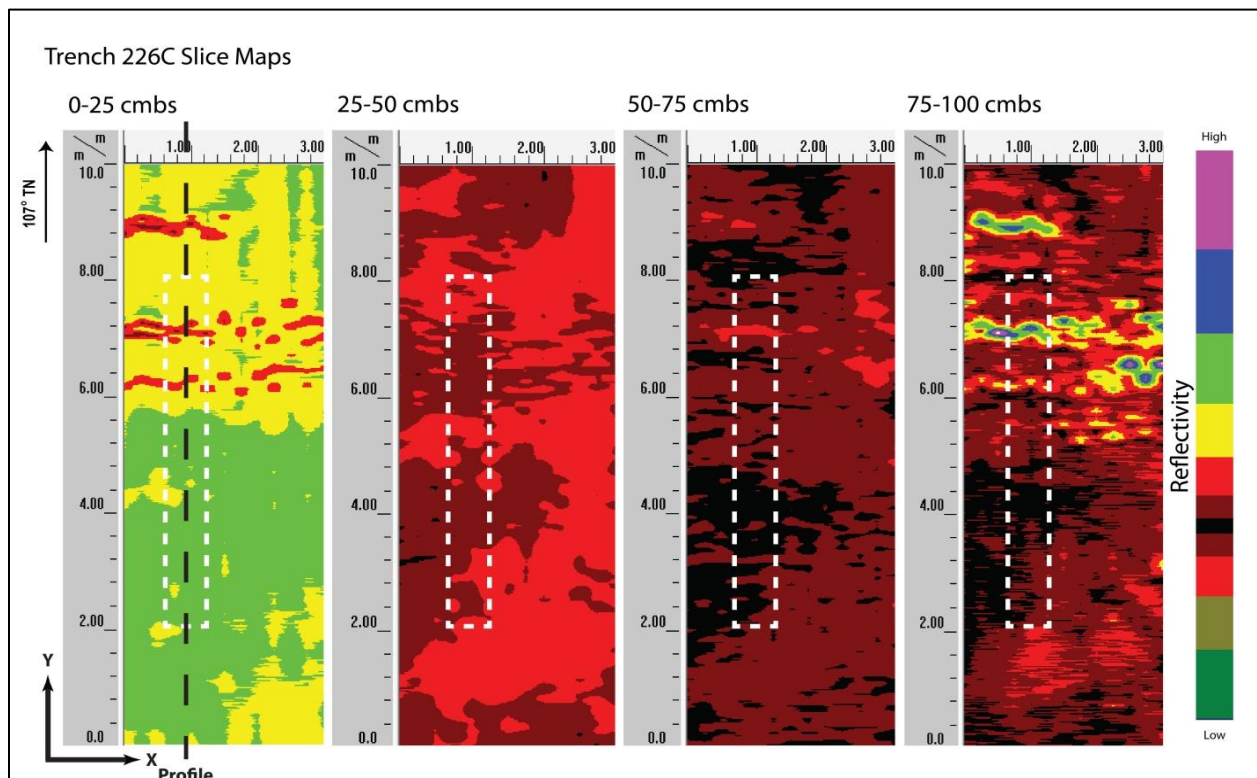


Figure 253. Slice maps of T-226C at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 254). Strata Ia and Ib were all clearly observed and occurred near the ground-truthed depths. Several electrical PVC pipes were found 0.36 mbs. These pipes did not show up on the profile or slice maps. This may be due to the fact that the pipes were comprised of PVC, very small, or similar in density to the surrounding stratum. No other discrete objects were observed in the GPR results or subsequent excavation.

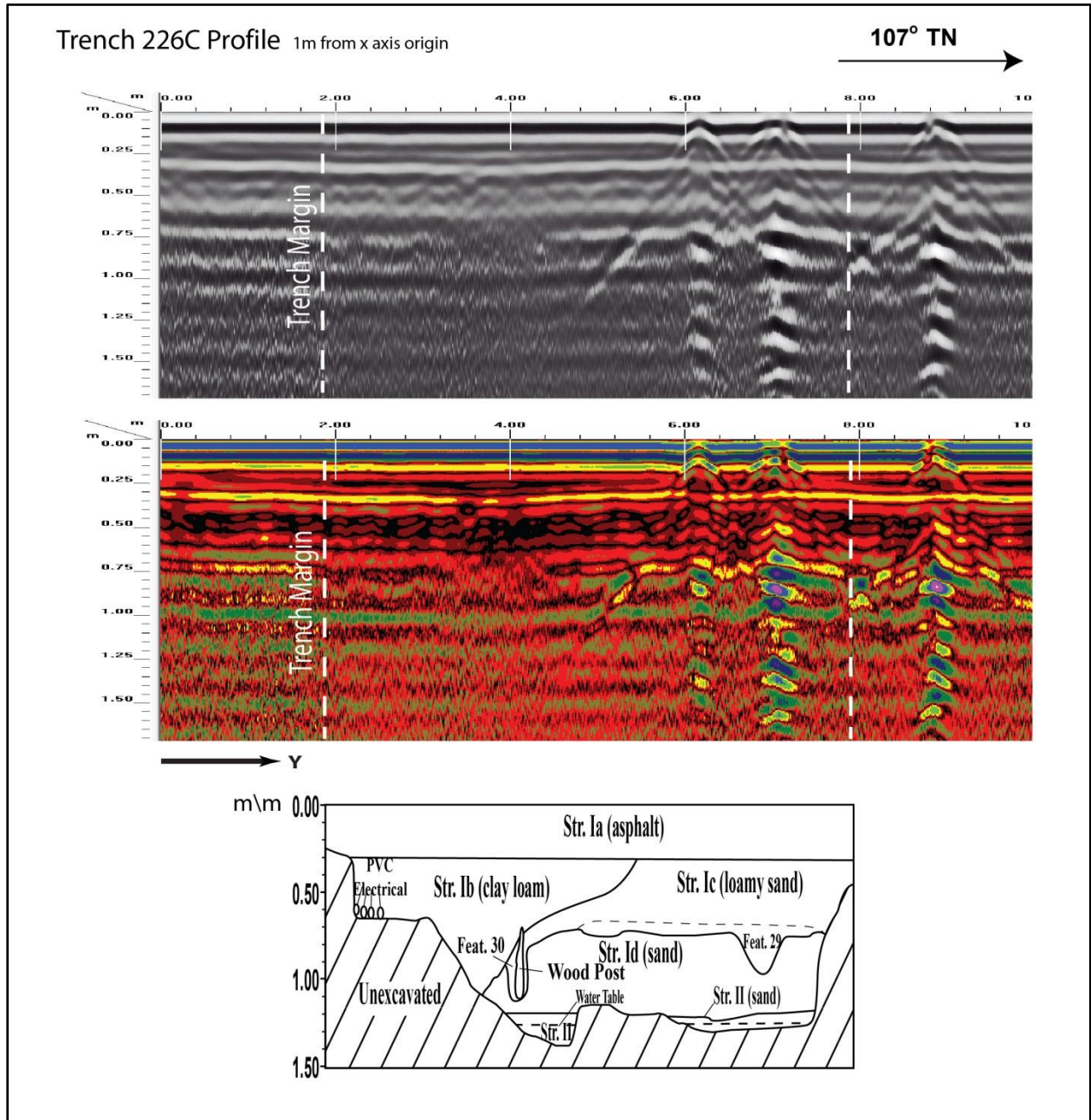


Figure 254. Visual comparison of excavated profile and GPR signal profile of T-226C

Test Excavation 226D

T-226D measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Punchbowl Street, 26.0 m northeast of Ala Moana Boulevard and Punchbowl Street intersection. The GPR grid measured 3.0 m by 10.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: cable line 3.5 m west. A pipe and metal beams were encountered 0.55 to 0.65 mbs in the eastern end of the excavation.

A review of amplitude slice maps indicated linear features that corresponded to the pipe and metal beams encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth except for the utilities. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs (Figure 255).

GPR depth profiles for T-226D identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 256). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.15 mbs and again around 0.4 mbs. An anomaly was observed in the profile and corresponded to the pipe and metal beams encountered during excavation. The maximum depth of clean signal return was approximately 1.0 mbs.

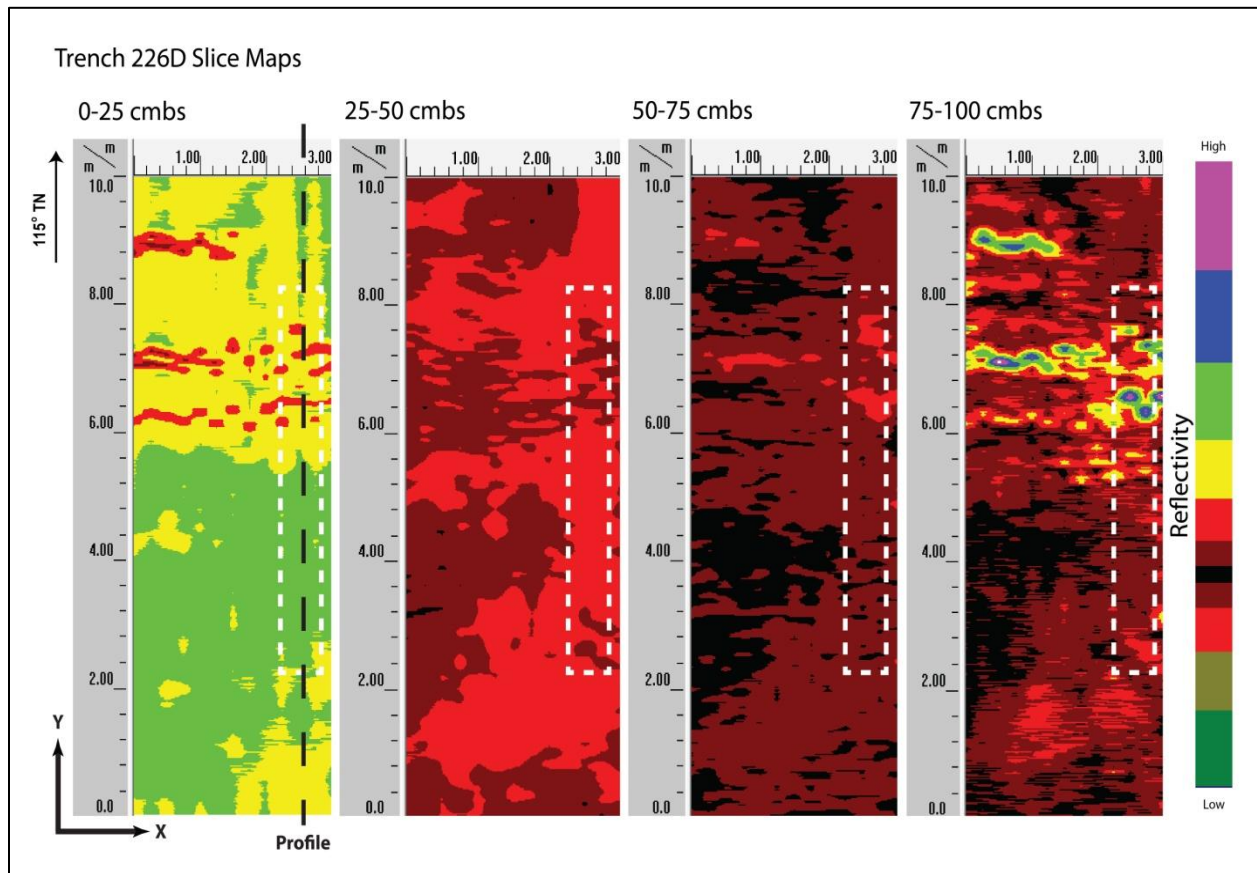


Figure 255. Slice maps of T-226D at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 256). Strata Ia to Ic were clearly observed and occurred at the ground-truthed depths. All other sediment transitions were below the maximum clean signal return depth. A utility pipe and metal beams were found 0.55-0.65 mbs. The pipe and beams corresponded to an anomaly observed in the profile. No other discrete objects were observed in the GPR results or subsequent excavation.

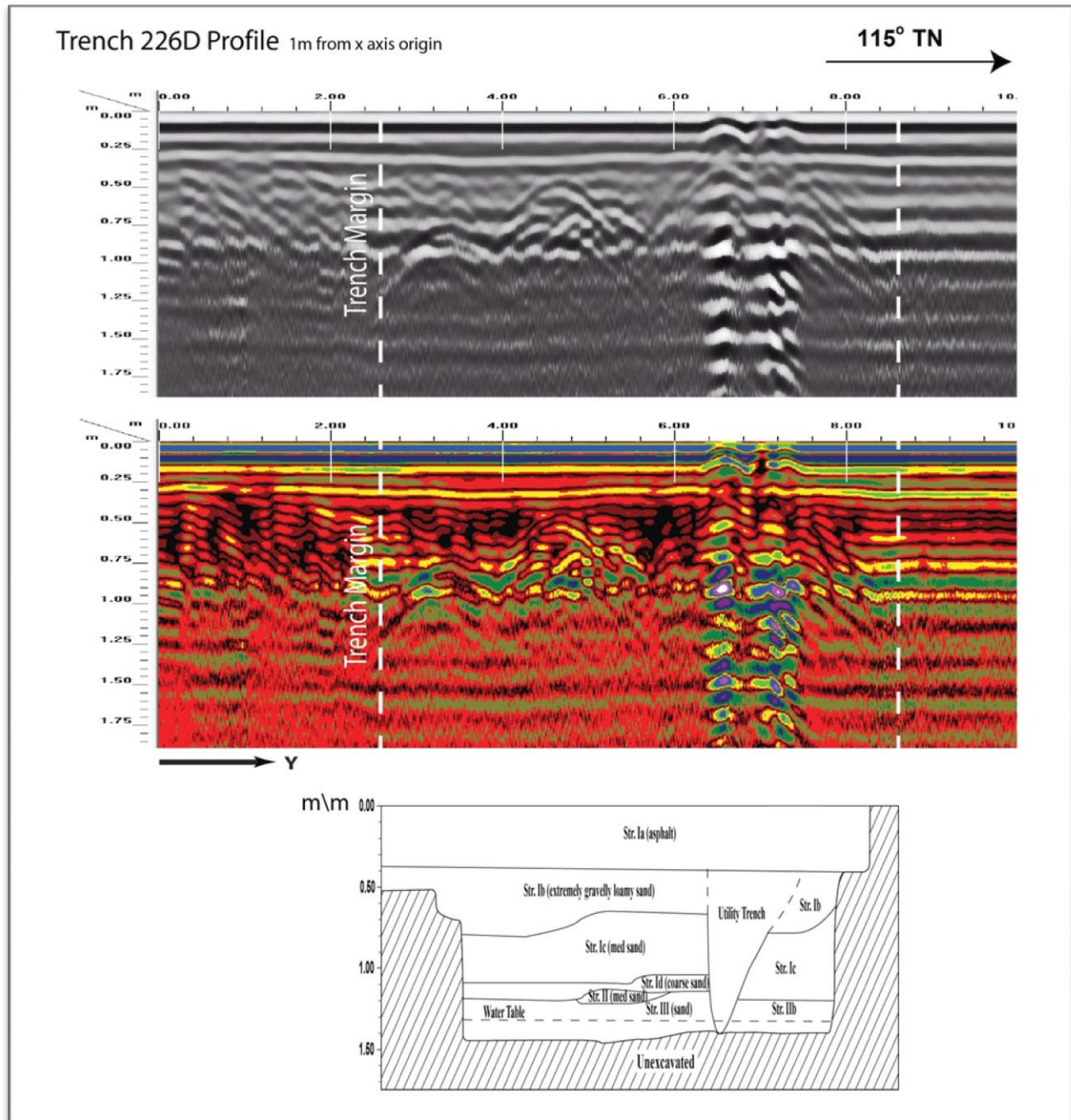


Figure 256. Visual comparison of excavated profile and GPR signal profile of T-226D

Test Excavation 227

T-227 measured 0.6 m by 6.0 m and was oriented northeast to southwest and was located within the road cut of Punchbowl Street, 13.0 m southwest of Punchbowl and Pohukaina Street intersection. The GPR grid measured 2.0 m by 9.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water line 1.5 m southeast. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 257).

GPR depth profiles for T-227 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 258). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.25 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 0.9 mbs.

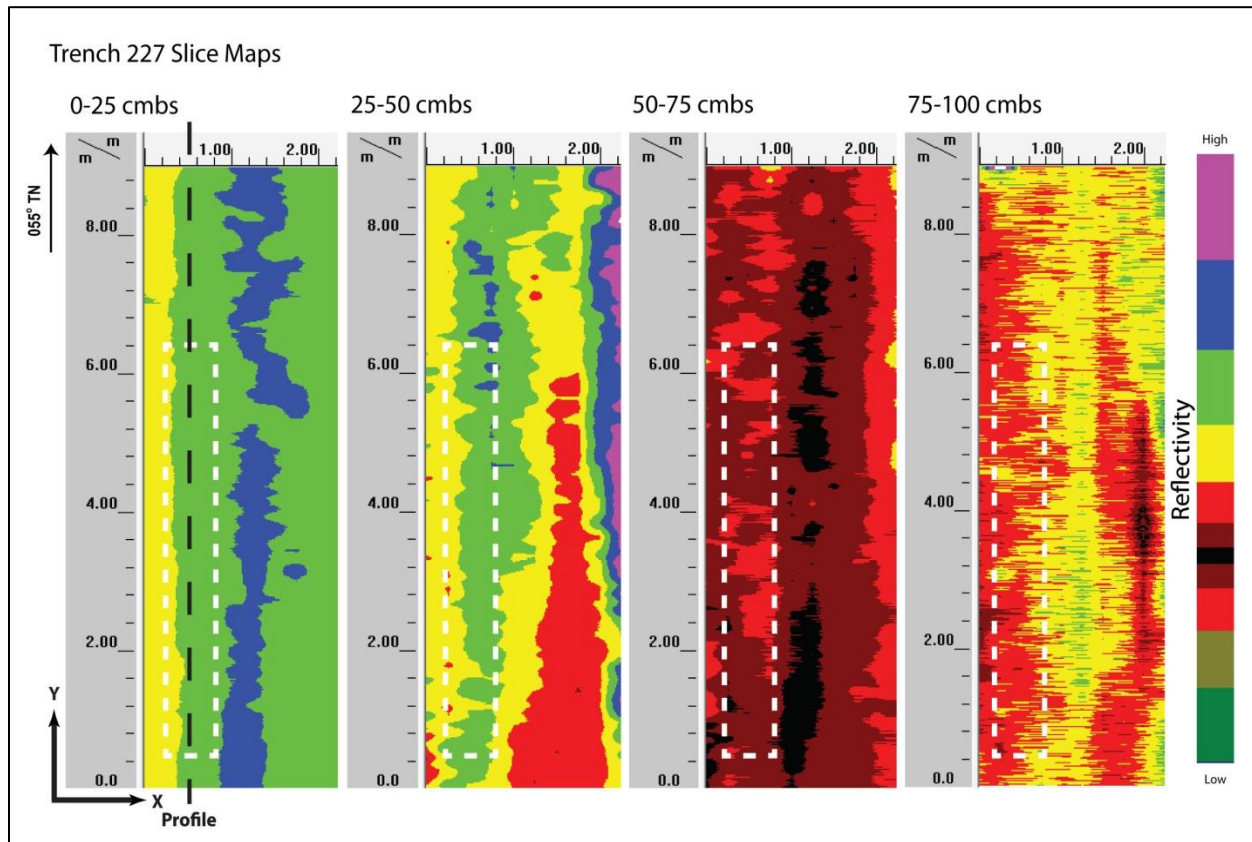


Figure 257. Slice maps of T-227 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 258). Strata Ia to II were clearly observed and occurred at the ground-truthed depths. Strata Ia through Id may be difficult to individually discern, possibly due to the fact that they were very thin layers of compacted fill, but based on reflectivity and horizontal banding it was apparent that there were multiple layers of fill events. All other sediment transitions were below the maximum clean signal return depth. No discrete objects were observed in the GPR results or subsequent excavation.

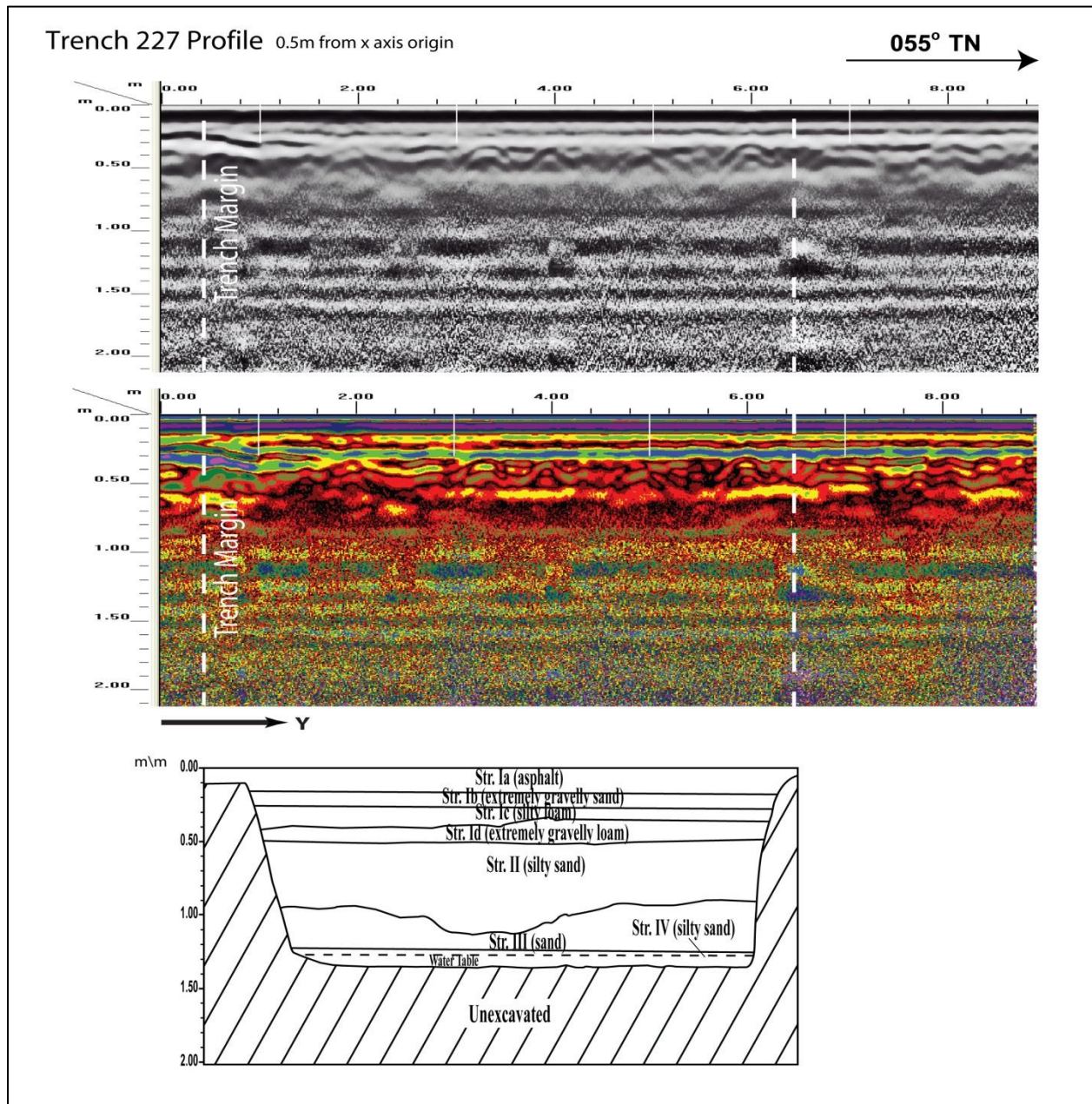


Figure 258. Visual comparison of excavated profile and GPR signal profile of T-227

Test Excavation 227A

T-227A measured 0.6 m by 6.0 m and was oriented northeast to southwest and was located within the road cut of Punchbowl Street, 17.0 m southwest of Punchbowl Street and Pohukaina Street intersection. The GPR grid measured 2.0 m by 9.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water line 1.1 m southeast, water drain 3.1 m southeast, and a sewer line 5.5 m southeast. A metal utility line was encountered 0.8 mbs in the southwest end and partial human burial was encountered 1.25 mbs in the northeastern end of the excavation.

A review of amplitude slice maps indicated no linear features although a utility was encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs (Figure 259).

GPR depth profiles for T-227A identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 260). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.25 mbs. No utilities were observed in the profile however a utility was encountered during excavation. The maximum depth of clean signal return was approximately 0.8 mbs.

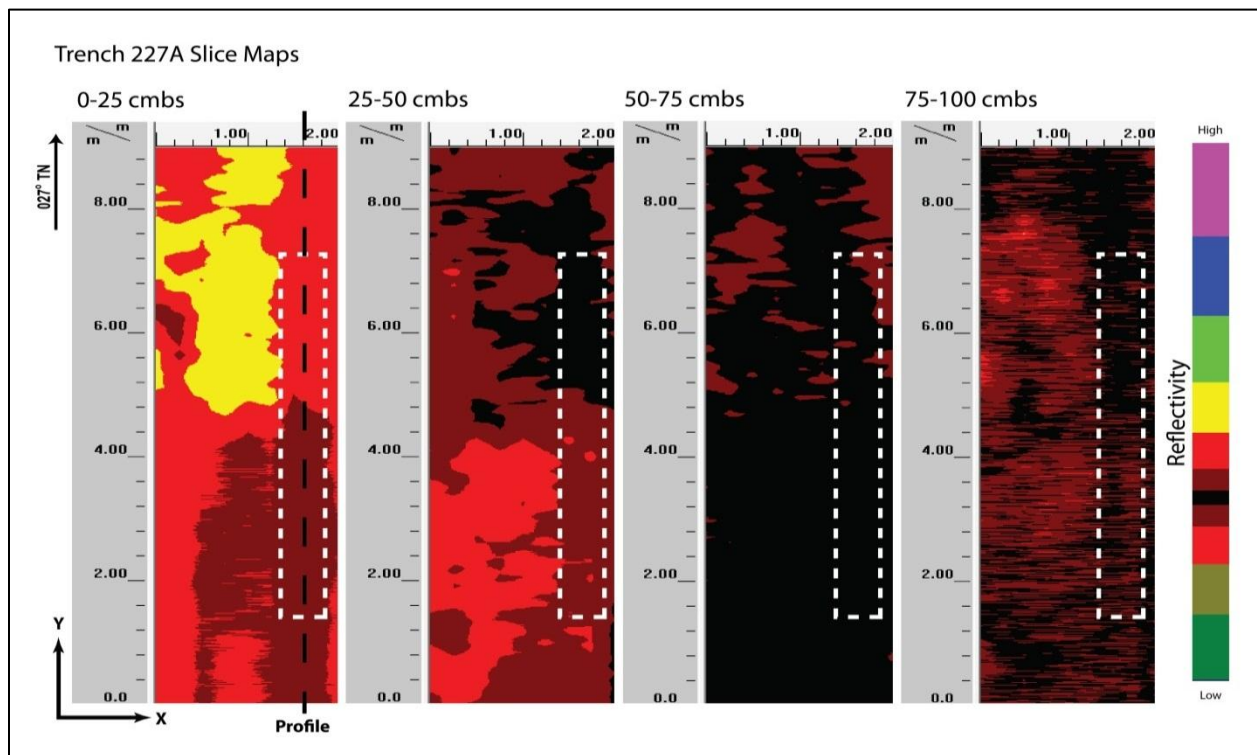


Figure 259. Slice maps of T-227A at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 260). Strata Ia and Ib were clearly observed and occurred at the ground-truthed depths. A metal utility pipe was found 0.8 mbs. This pipe did not show up on the profile or slice maps. This may be due to the fact that it was empty or had a small diam. A partial human burial was found 1.25 mbs but did not show up on the profile or slice maps due to it being below maximum clean signal return depth. No other discrete objects were observed in the GPR results or subsequent excavation.

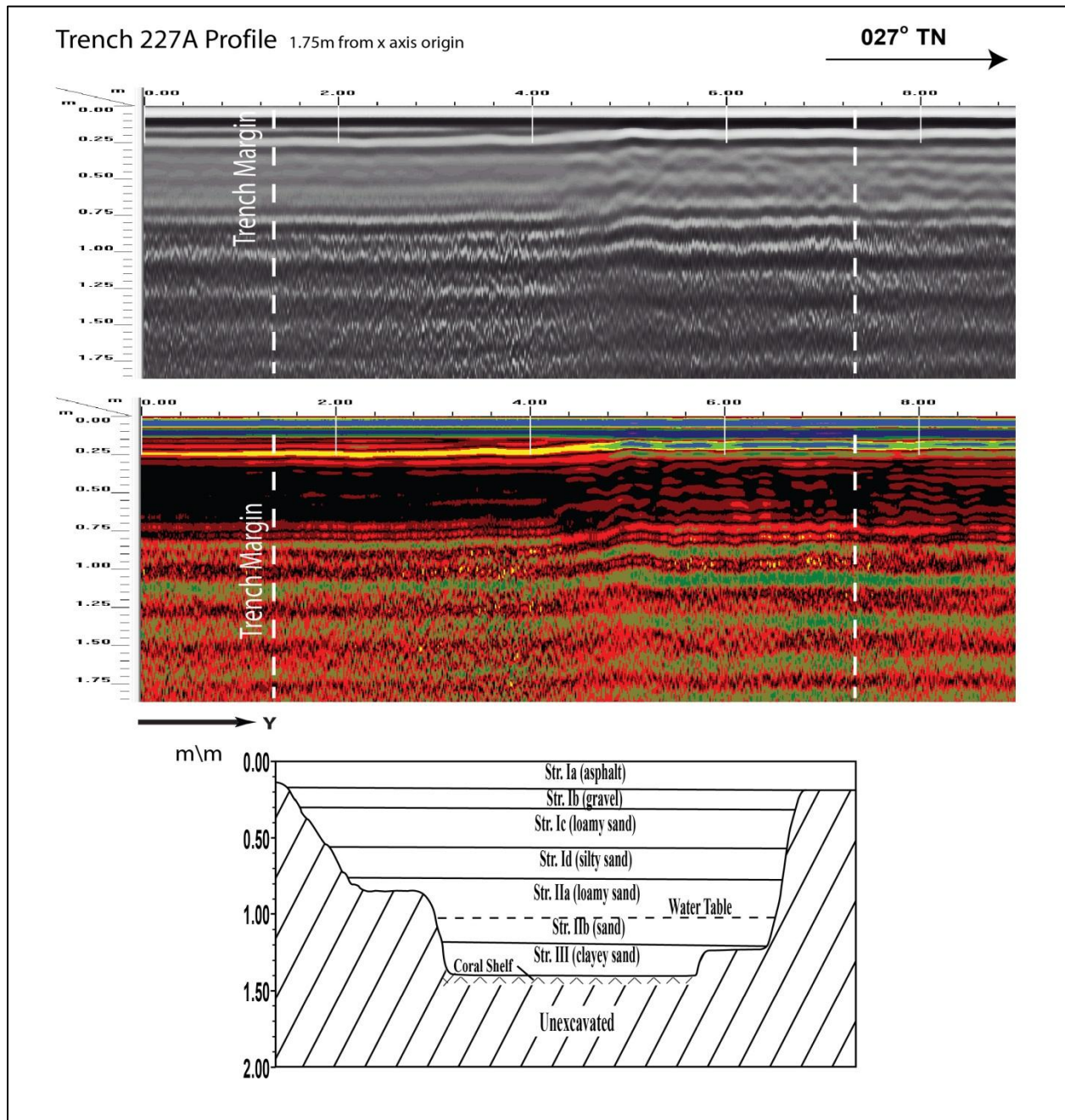


Figure 260. Visual comparison of excavated profile and GPR signal profile of T-227A

Test Excavation 227B

T-227B measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Pohukaina Street, 18.0 m southeast of Pohukaina Street and Punchbowl Street intersection. The GPR grid measured 3.0 m by 10.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water line 2.0 m southwest, gas line 2.0 m northeast, water drain 2.75 m northwest. An abandoned utility pipe was encountered 0.6 mbs in the southern end of the excavation.

A review of amplitude slice maps indicated no linear features although a utility was encountered during excavation. Reflectivity was relatively uniform throughout the grid. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs and increases again around 0.75 mbs (Figure 261).

GPR depth profiles for T-227B identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 262). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.3 mbs. No utilities or anomalies were observed in the profile. The maximum depth of clean signal return was approximately 1.25 mbs.

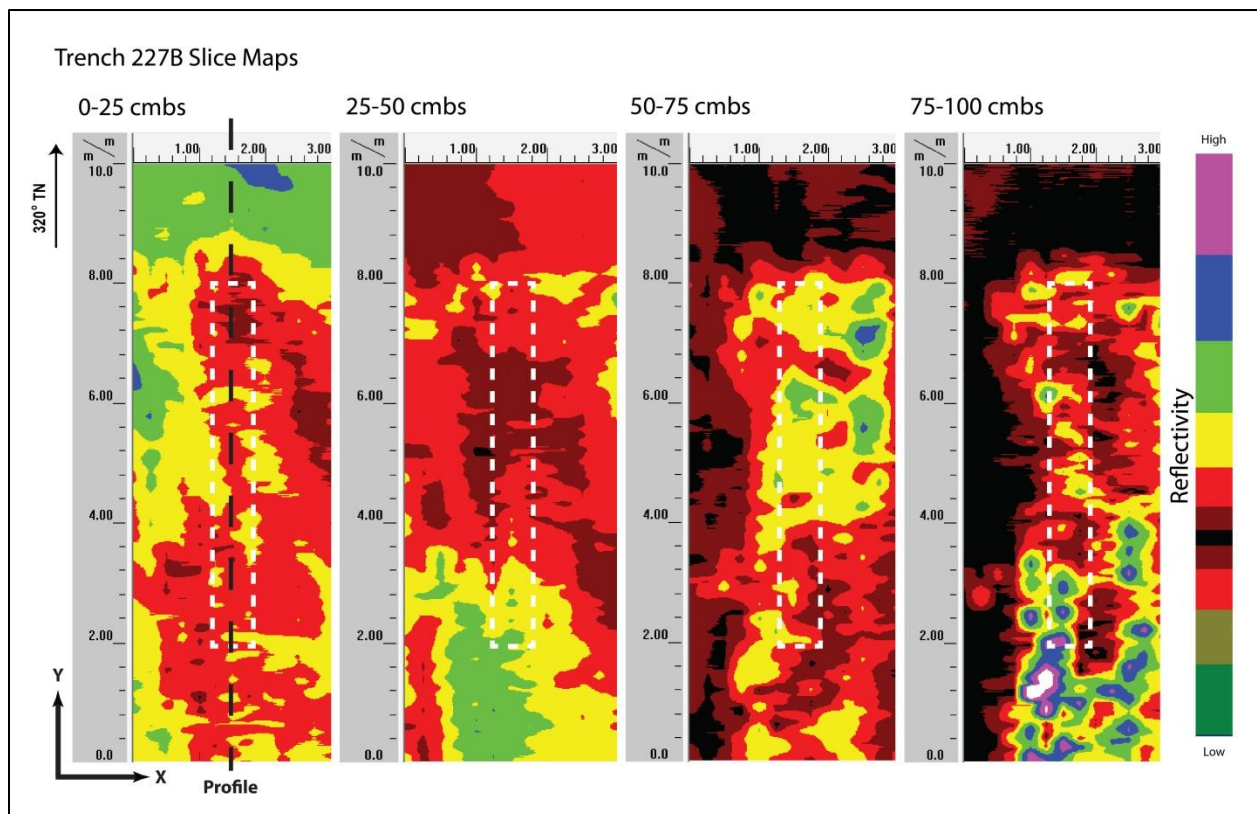


Figure 261. Slice maps of T-227B at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 262). Strata Ia to Ib were clearly observed and occurred at the ground-truthed depths. An increase in reflectivity was observed around 0.6 mbs and may represent sand that was observed at this depth. A utility pipe was found 0.6 mbs. This pipe did not show up in the profile or slice maps. This may be due to the fact that the pipe was empty or had a small diam. No other discrete objects were observed in the GPR results or subsequent excavation.

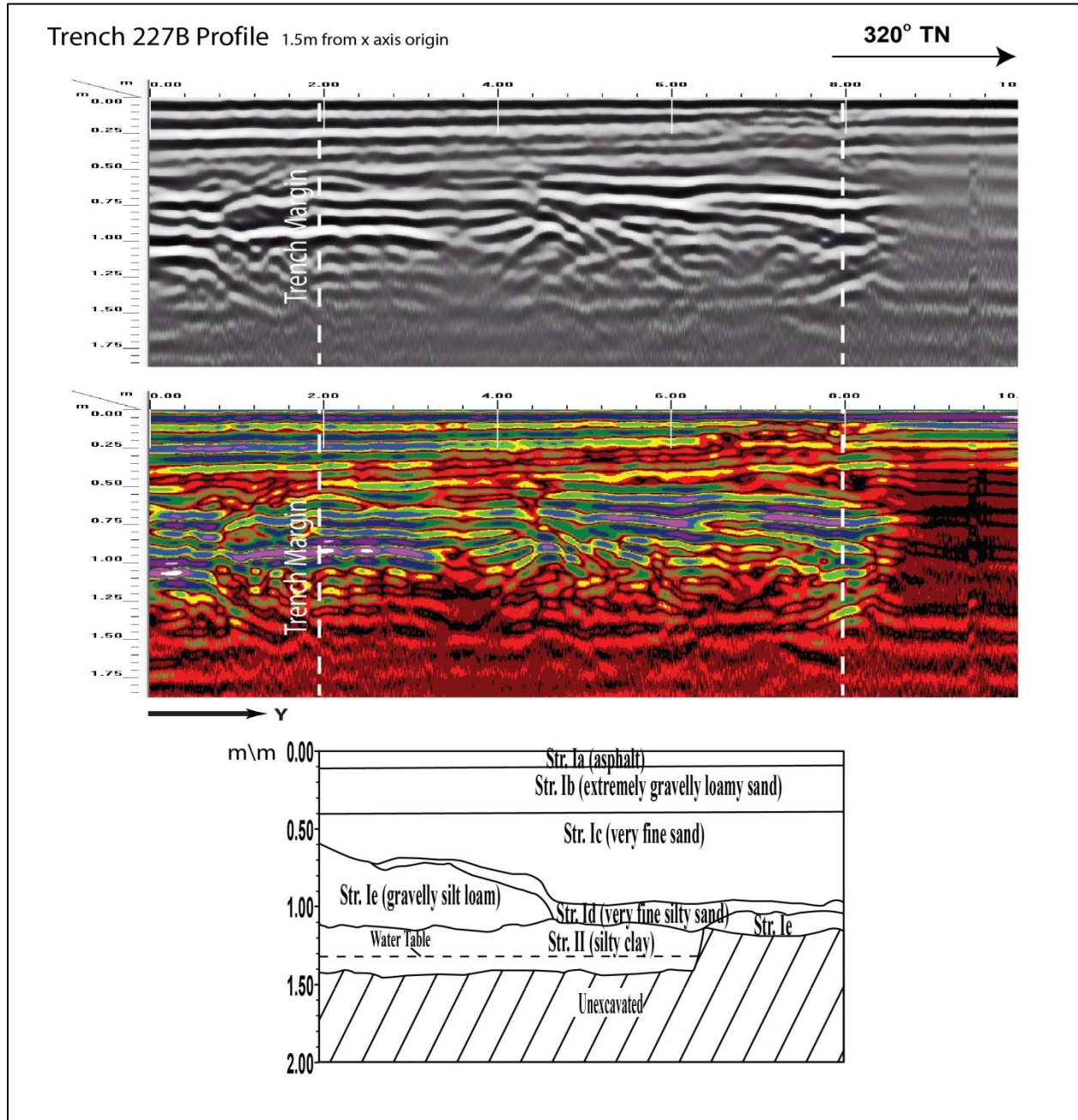


Figure 262. Visual comparison of excavated profile and GPR signal profile of T-227B

Test Excavation 228

T-228 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Pohukaina Street, 85.0 m northwest of Pohukaina Street and South Street intersection. The GPR grid measured 2.5 m by 10.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: sewer line 3.5 m southwest, water line 5.6 m southwest. No utilities transected the excavation location.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 263).

GPR depth profiles for T-228 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 264). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.35 mbs. Anomalies were observed in the profile but not within the excavation boundaries. The maximum depth of clean signal return was approximately 1.0 mbs.

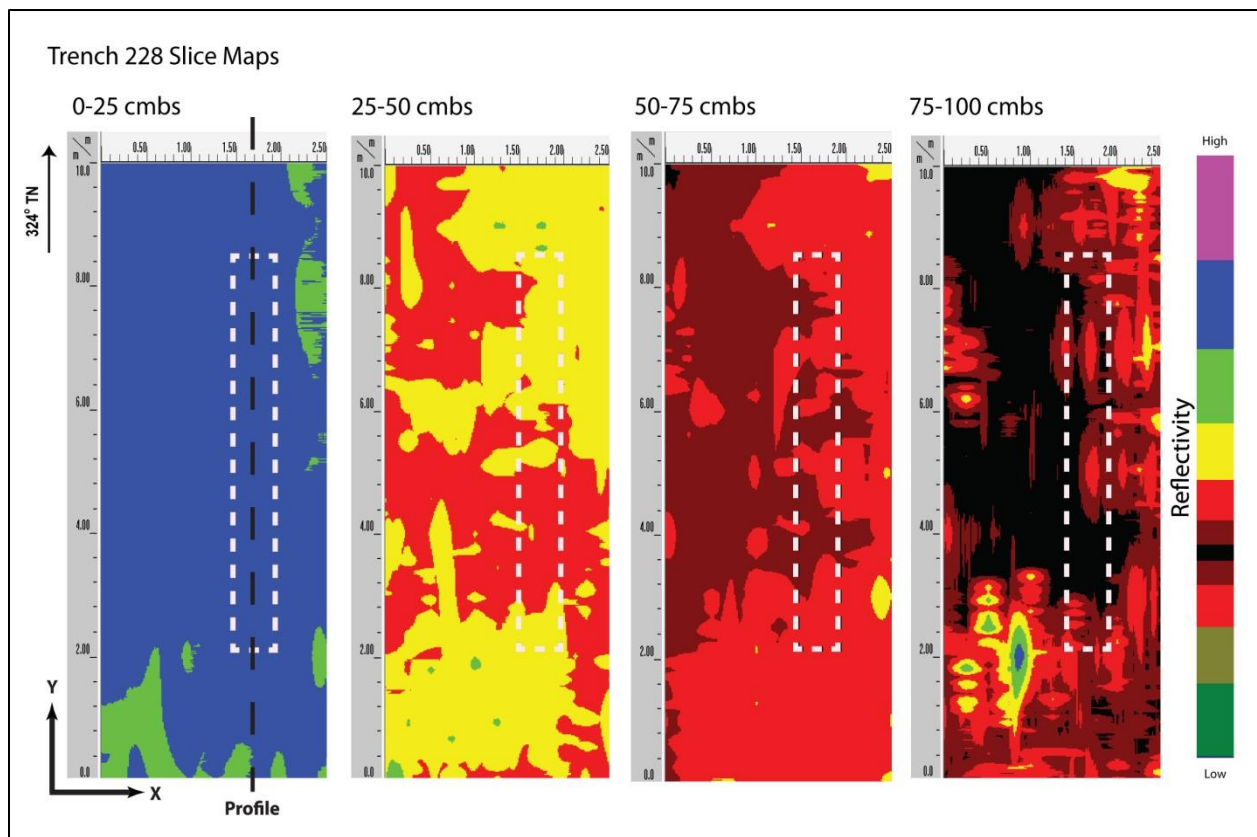


Figure 263. Slice maps of T-228 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 264). Strata Ia to Ic were all clearly observed and occurred near the ground-truthed depths. Strata included: asphalt, very gravelly sandy loam fill, extremely stony, cobbly, gravelly sand fill, sand fill, and extremely gravelly to stony cinder fill. No discrete objects or other stratigraphic transitions were observed in the GPR results or subsequent excavation.

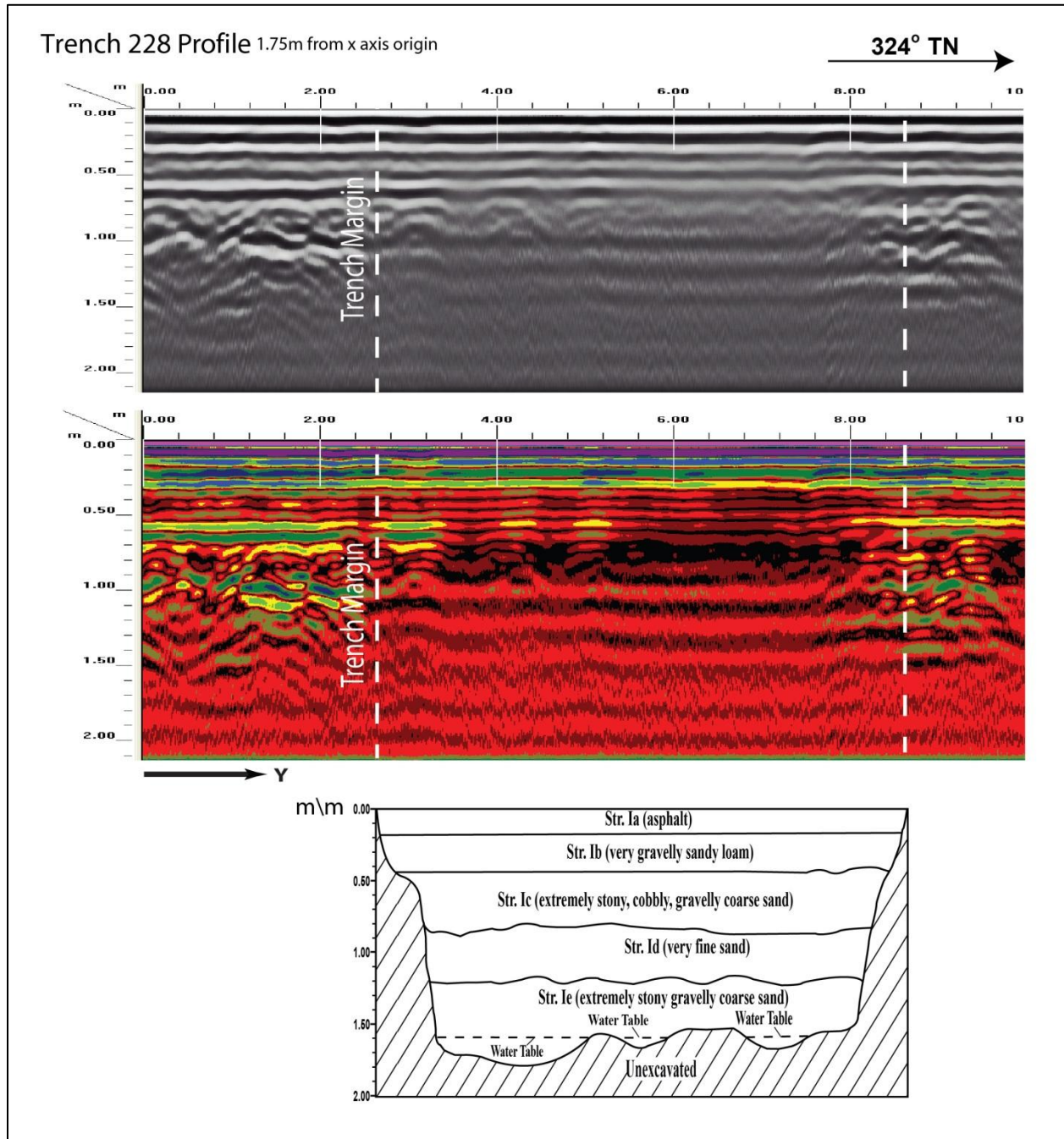


Figure 264. Visual comparison of excavated profile and GPR signal profile of T-228

Test Excavation 228A

T-228A measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Pohukaina Street, 57.0 m southeast of Pohukaina Street and Punchbowl Street intersection. The GPR grid measured 3.0 m by 10.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: gas line 0.6 m southwest, sewer line 2.5 m southwest and 4.4 m southeast, water line 2.8 m northwest. No utilities transected the excavation location.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs and increases again around 0.75 mbs (Figure 265).

GPR depth profiles for T-228A identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 266). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.15 mbs and again at 0.5 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 1.3 mbs.

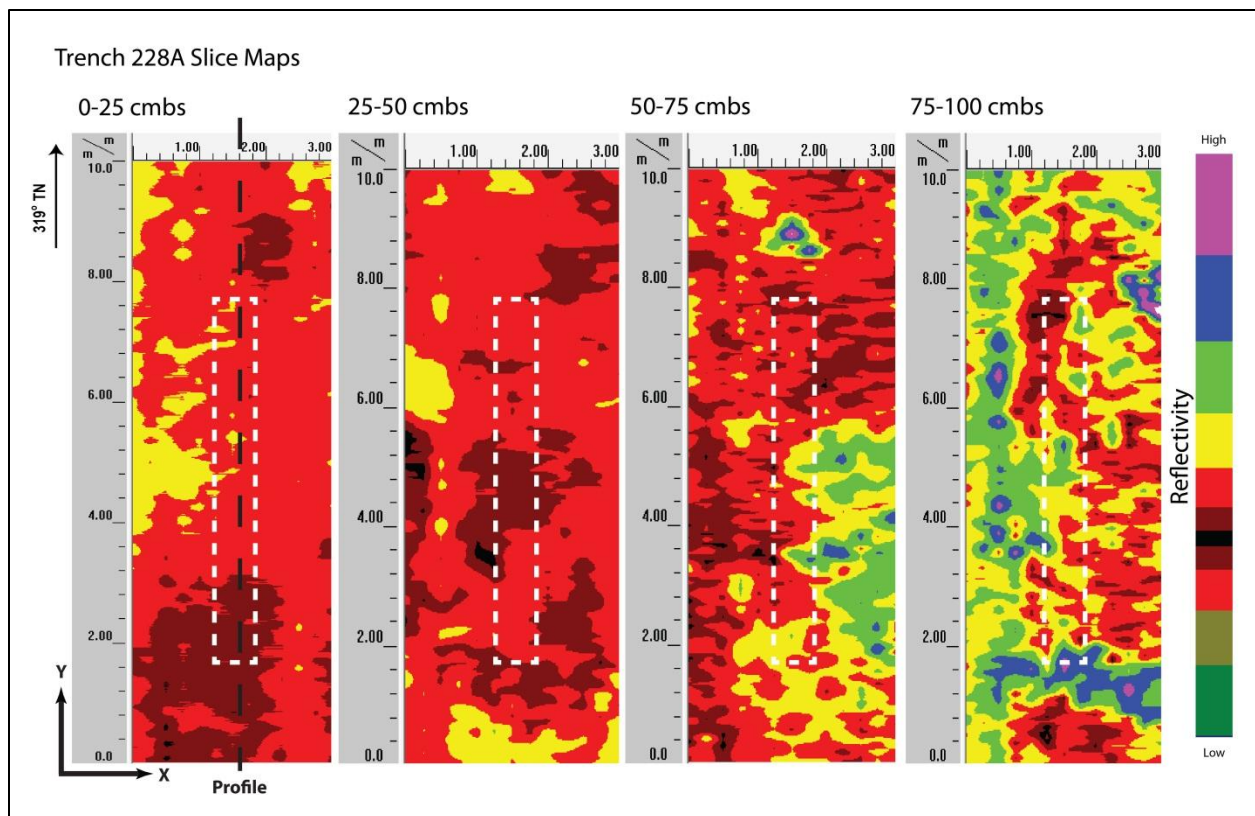


Figure 265. Slice maps of T-228A at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 266). Strata Ia to Ie were all clearly observed and occurred at the ground-truthed depths. Strata included: asphalt, very gravelly sandy loam fill, very gravelly sandy loam fill, loamy sand fill, sand fill, loamy sand fill, loamy sand fill, natural sandy clay, and natural sandy clay. No discrete objects or other stratigraphic transitions were observed in the GPR results or subsequent excavation.

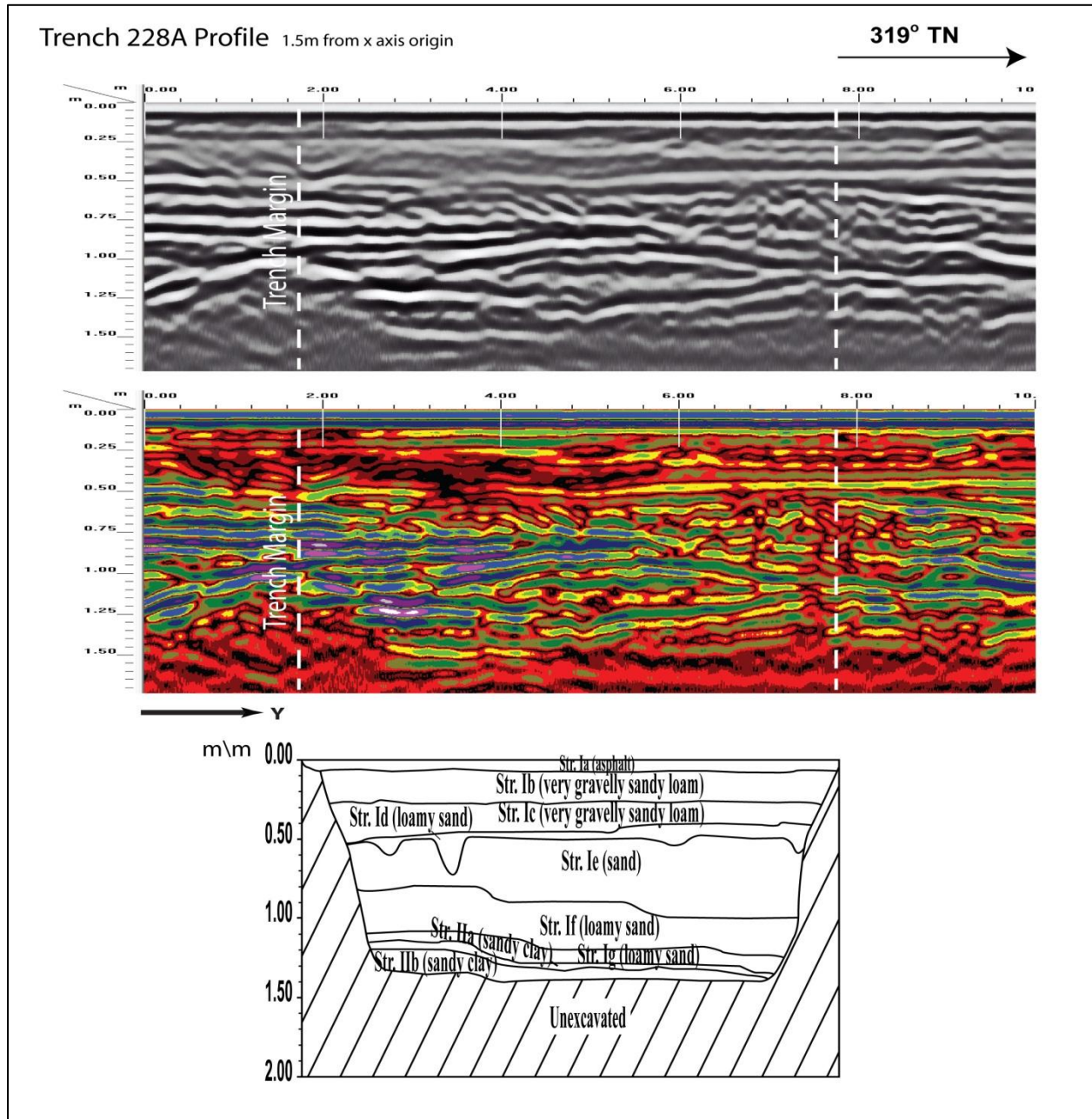


Figure 266. Visual comparison of excavated profile and GPR signal profile of T-228A

Test Excavation 229

T-229 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Pohukaina Street, 55.0 m southeast of Pohukaina Street and South Street intersection. The GPR grid measured 2.0 m by 9.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water drain 0.2 m northeast, sewer line 3.8 m southwest. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 267).

GPR depth profiles for T-229 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 268). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.25 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 1.0 mbs.

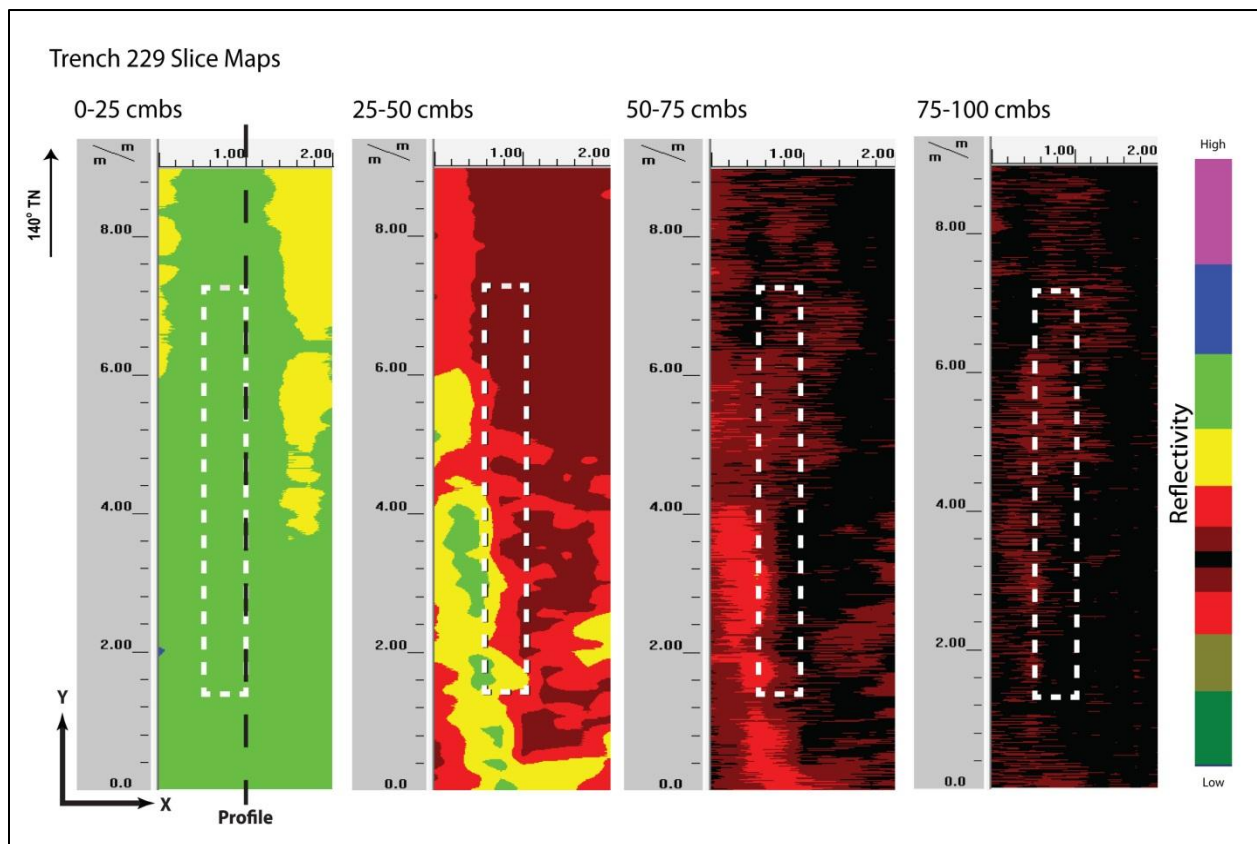


Figure 267. Slice maps of T-229 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a weak correlation in stratigraphic transitions (Figure 268). Strata included: asphalt, basalt gravel, gravelly sandy loam fill, incinerator layer, sandy clay loam fill, extremely cobbly sandy silt fill, sandy clay fill, sandy clay fill, natural sandy clay, and the coral shelf. These transitions were not clearly depicted in the GPR profile at the depths that they occurred. No other sediment transitions or discrete objects were observed in the GPR results or subsequent excavation.

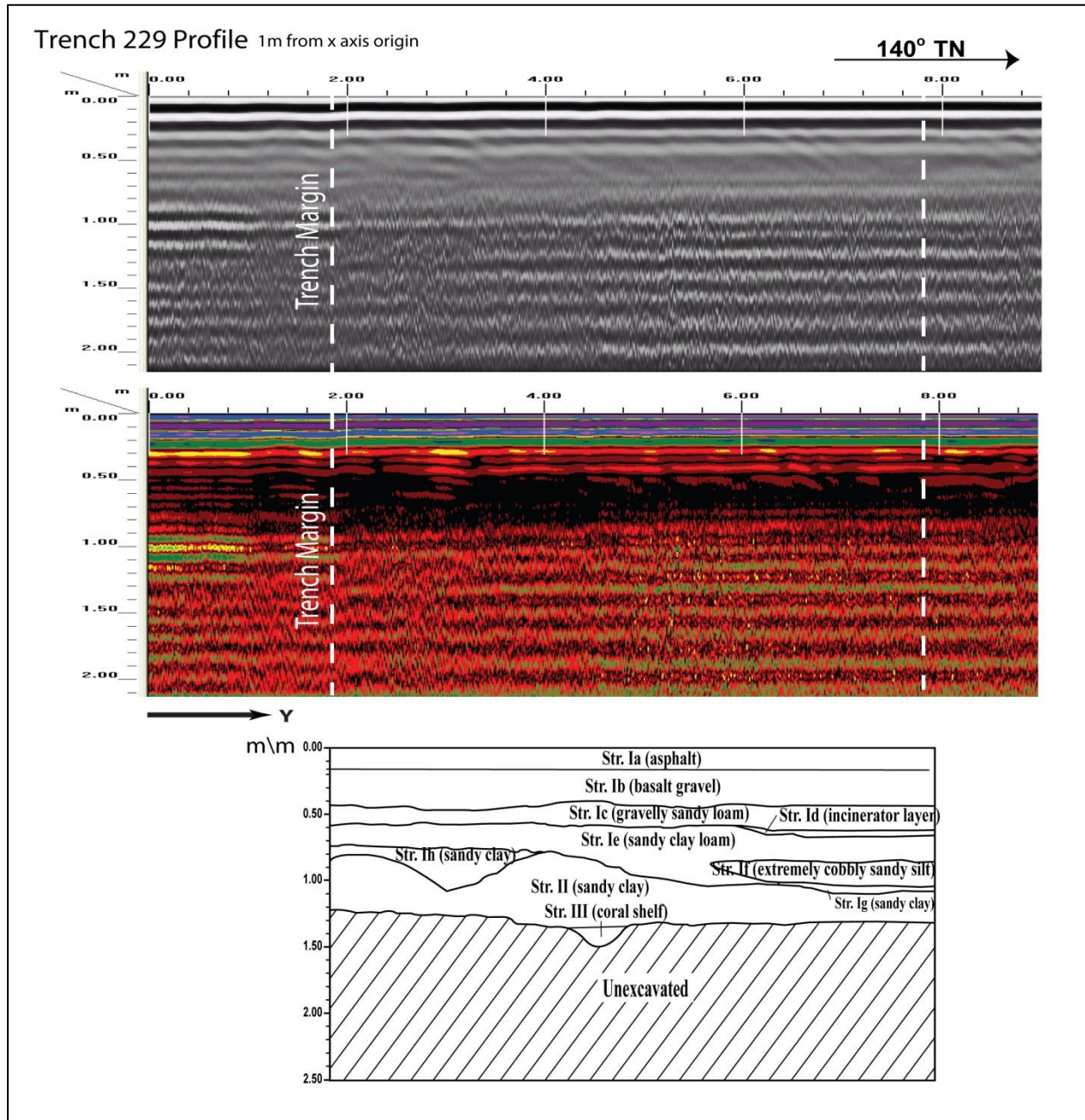


Figure 268. Visual comparison of excavated profile and GPR signal profile of T-229

Test Excavation 230

T-230 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Pohukaina Street, 21.0 m southeast of Pohukaina Street and Keawe Street intersection. The GPR grid measured 2.0 m by 9.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water drain 1.2 m northeast, sewer line 1.8 m southwest. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might indicate the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs (Figure 269).

GPR depth profiles for T-230 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 270). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.1 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 1.0 mbs.

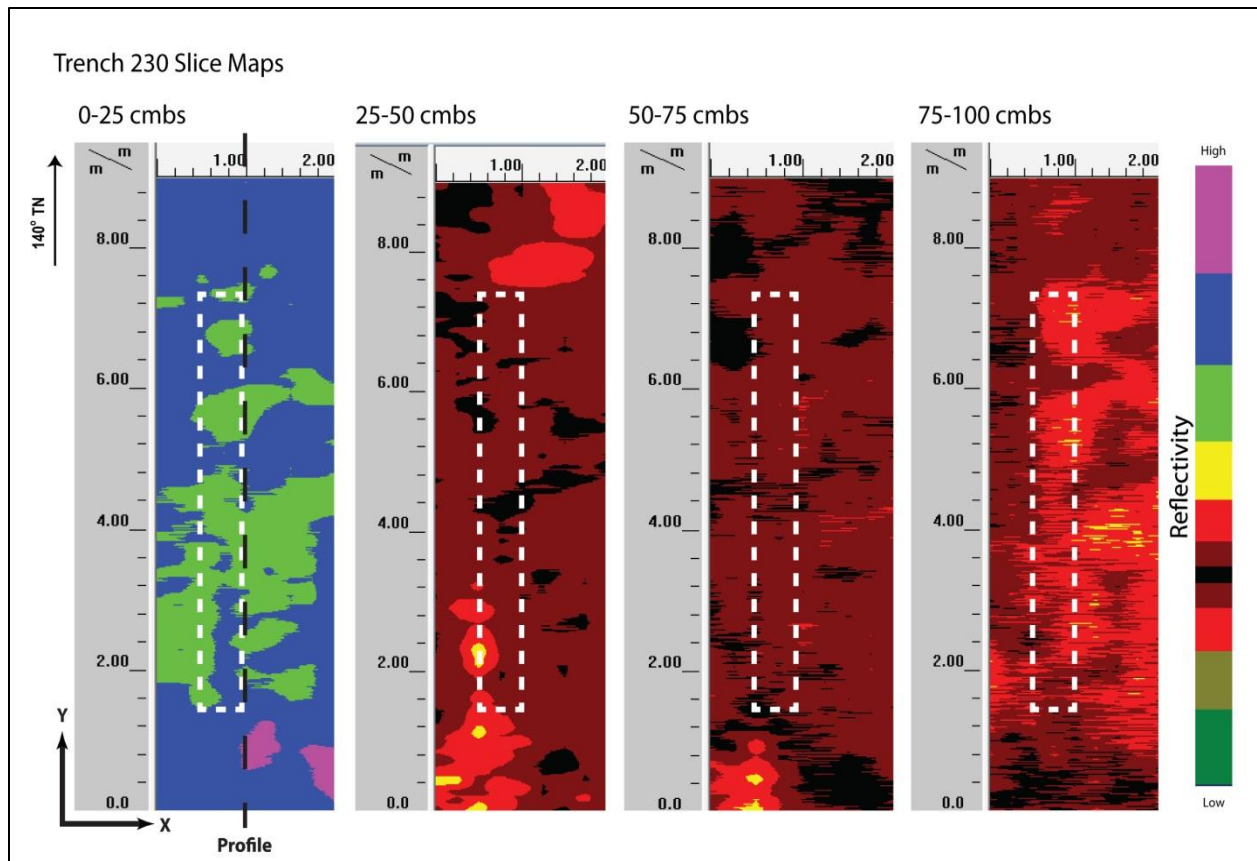


Figure 269. Slice maps of T-230 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a weak correlation in stratigraphic transitions (Figure 270). Strata included: asphalt, gravel, gravel and cobbles, clay fill, gravelly sandy loam fill, natural clay, and natural sand. These transitions were not clearly depicted in the GPR profile at the depths that they occurred. No other sediment transitions or discrete objects were observed in the GPR results or subsequent excavation.

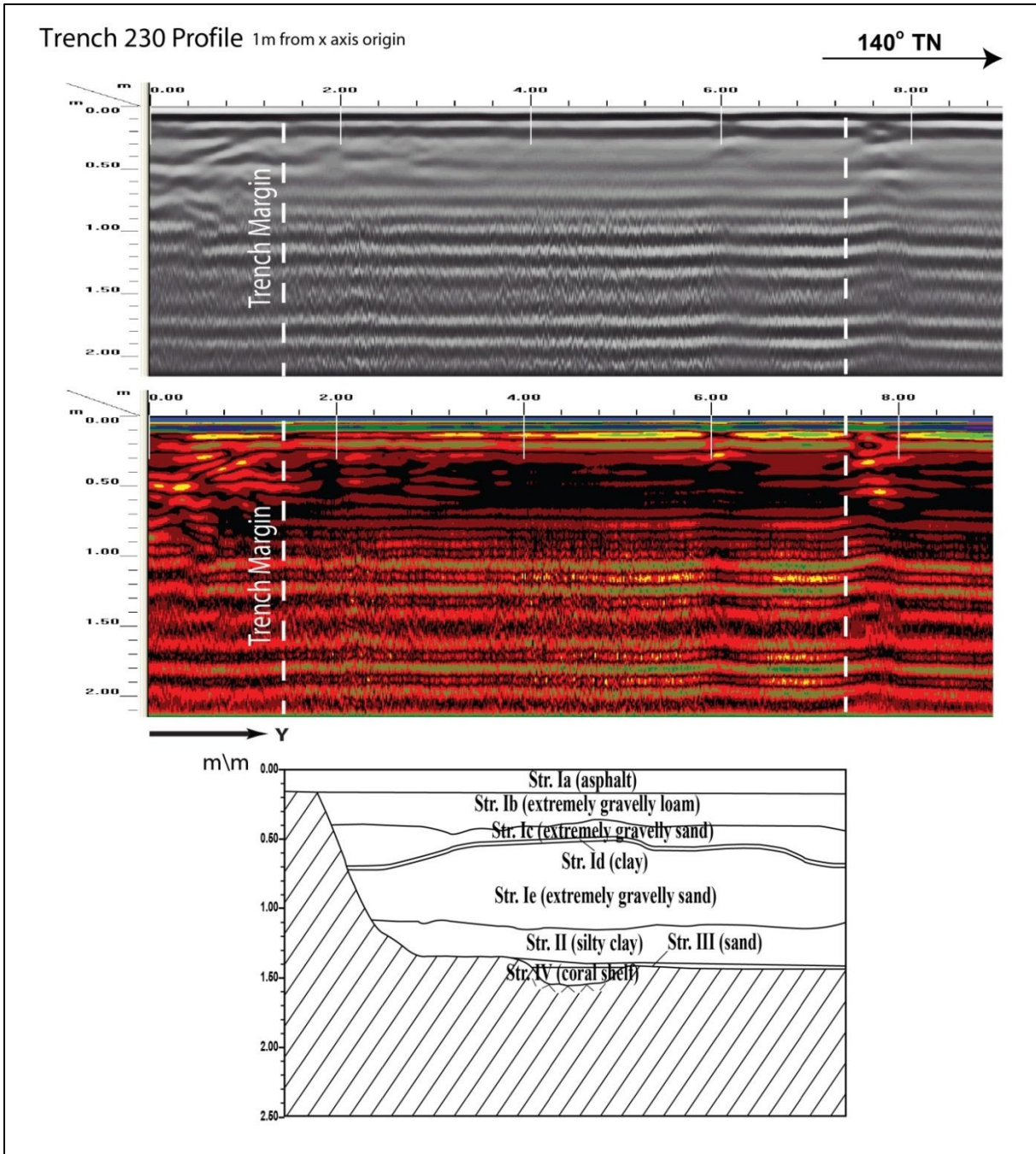


Figure 270. Visual comparison of excavated profile and GPR signal profile of T-230

Test Excavation 231

T-231 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Pohukaina Street, 6 m northwest of Pohukaina Street and Lana Lane intersection. The GPR grid measured 3.0 m by 10.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: sewer line runs from northwest end to southeast end of excavation, water line 3.7 m northeast. A 12" sewer line was encountered 1.3 mbs running the full length and through the center of the excavation location.

A review of amplitude slice maps indicated a linear feature which could corresponded to the sewer line that was encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs (Figure 271).

GPR depth profiles for T-231 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 272). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.2mbs and again around 0.7 mbs. An anomaly was observed in the profile and seems to corresponded to the sewer line that was encountered during excavation. The maximum depth of clean signal return was approximately 1.4 mbs.

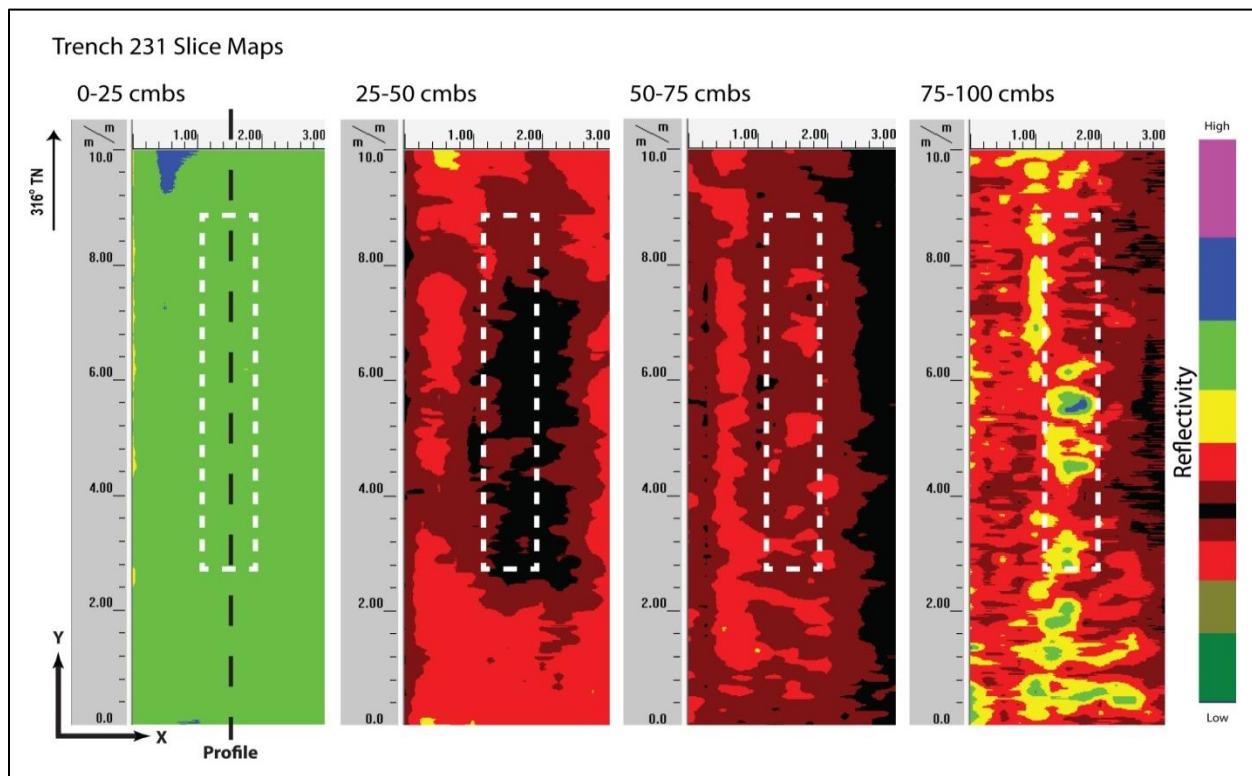


Figure 271. Slice maps of T-231 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 272). Strata Ia to Ib were clearly observed and occurred near the ground-truthed depths. Strata included: asphalt, extremely gravelly loam, extremely gravelly sand, silty sand fill, and sand fill. A sewer line was found 1.3 mbs. This corresponded to an increase in reflectivity and hyperbola around the same depth. No other discrete objects were observed in the GPR results or subsequent excavation.

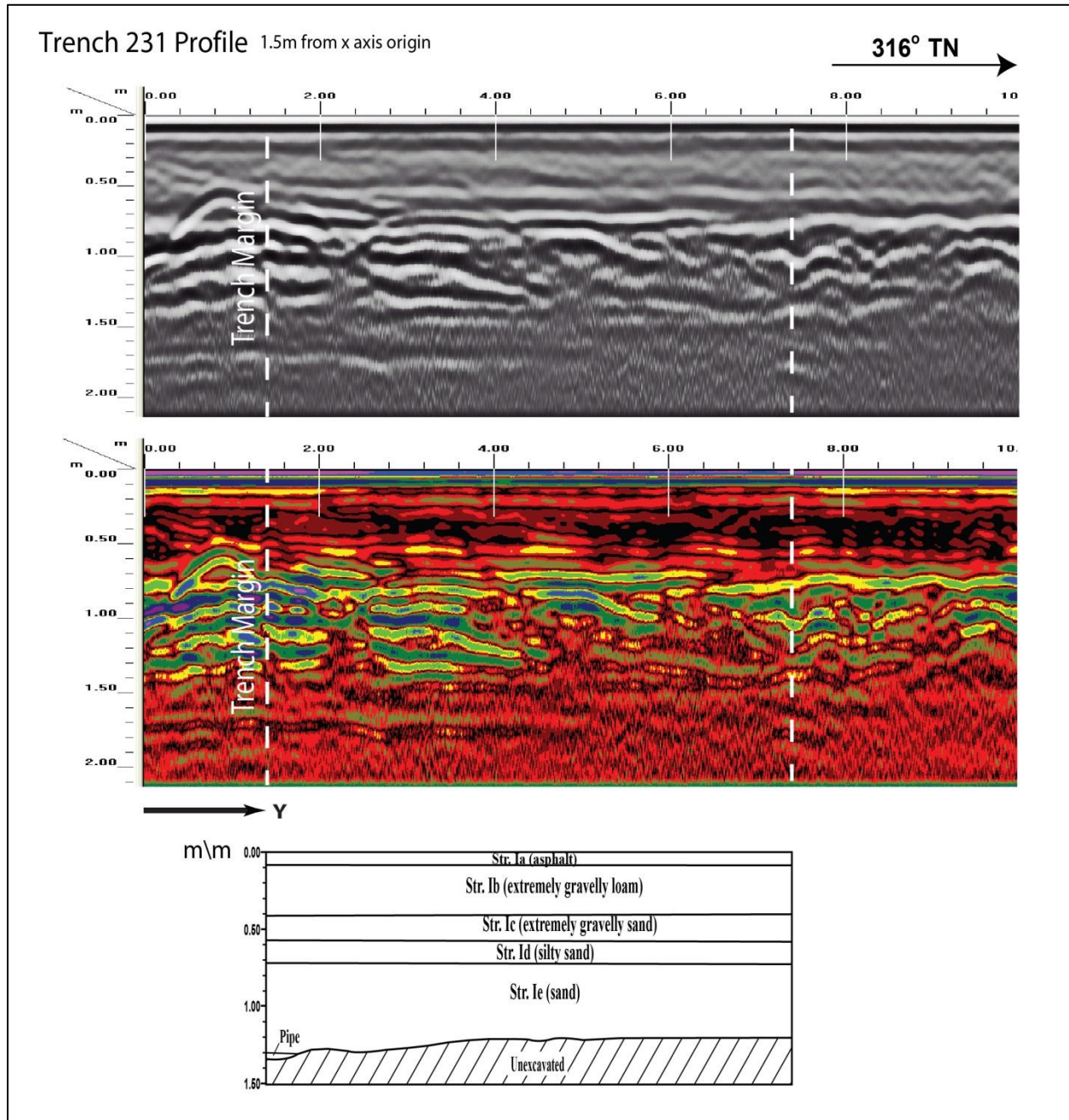


Figure 272. Visual comparison of excavated profile and GPR signal profile of T-231

Test Excavation 231A

T-231A measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Pohukaina Street, 8.0 m north of Pohukaina Street and Lana Lane intersection. The GPR grid measured 3.0 m by 10.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water line 4.3 m southwest, sewer line 8.1 m southeast. Two metal utility pipes were encountered at 0.55 mbs and 1.26 mbs in the northwest side of the excavation.

A review of amplitude slice maps indicated no linear features although two utilities were encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs (Figure 273).

GPR depth profiles for T-231A identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 274). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.15 mbs and again around 0.6 mbs. An anomaly was observed in the profile but was not observed during excavation and does not corresponded to the utilities encountered. The maximum depth of clean signal return was approximately 0.8 mbs.

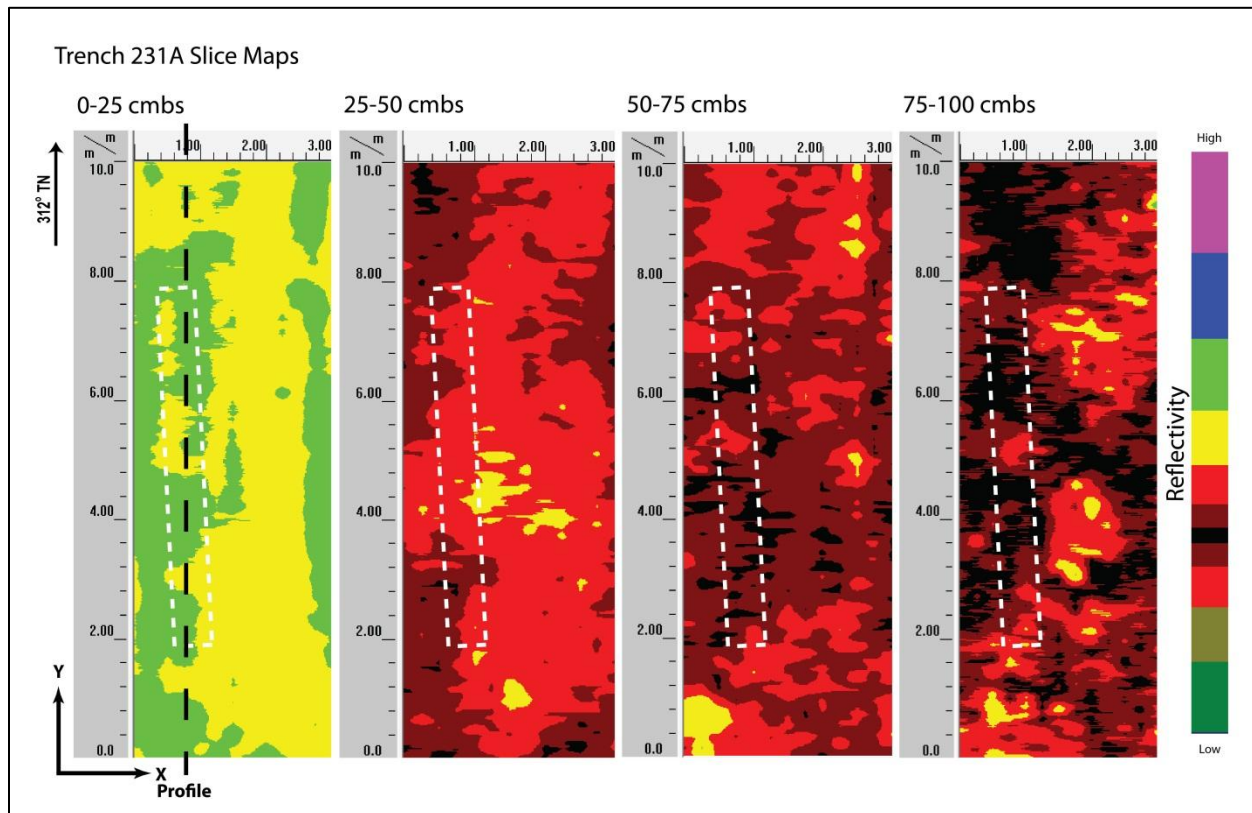


Figure 273. Slice maps of T-231A at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 274). Strata Ia and Ib were clearly observed and occurred at the ground-truthed depths. Textural changes in the form of multiple small hyperbolas were apparent in Stratum Ib which was extremely gravelly silty sand fill. All other sediment transitions were below the maximum clean signal return depth. Two metal pipes were found 0.55 and 1.26 mbs. The two pipes did not show up in the profile or slice maps. This may be due to the fact that the pipes may have had a similar density to the surrounding stratum or that they were empty. No other discrete objects were observed in the GPR results or subsequent excavation.

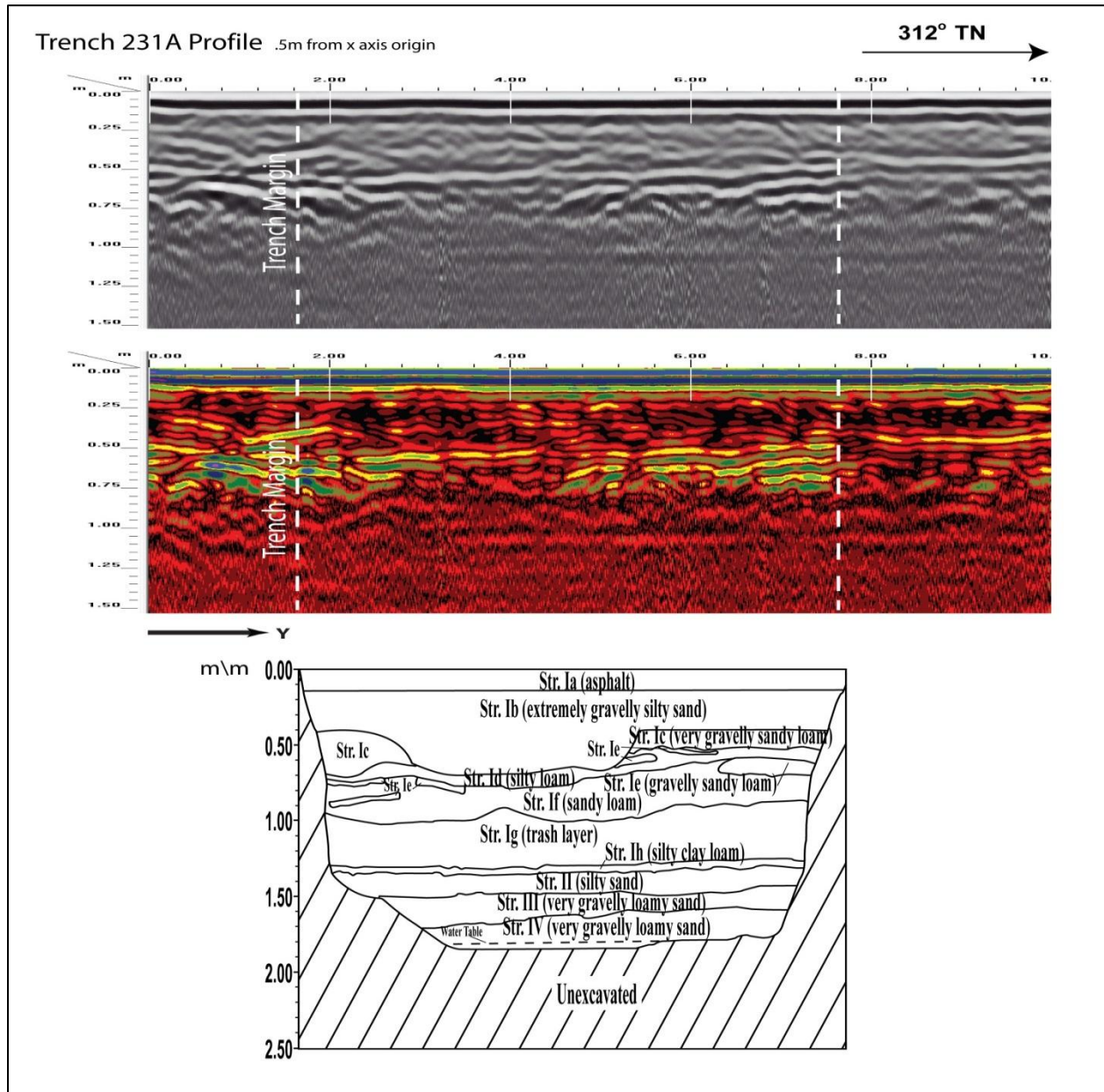


Figure 274. Visual comparison of excavated profile and GPR signal profile of T-231A

Test Excavation 232

T-232 measured 0.8 m by 6.0 m and was oriented northeast to southwest and was located in within the road cut of Cooke Street, 58.0 m northeast of Cooke Street and Pohukaina Street intersection. The GPR grid measured 2.0 m by 9.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: gas line less than a m northwest, water drain 2.5 m northwest, sewer line 2.6 m southeast, water line 5.6 m southeast. A gas line was encountered 0.4 mbs in the northeastern end of the excavation.

A review of amplitude slice maps indicated no linear features although a gas line was encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs (Figure 275).

GPR depth profiles for T-232 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 276). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.25 mbs. No utilities were observed in the profile although a gas line was encountered during excavation. The maximum depth of clean signal return was approximately 0.75 mbs.

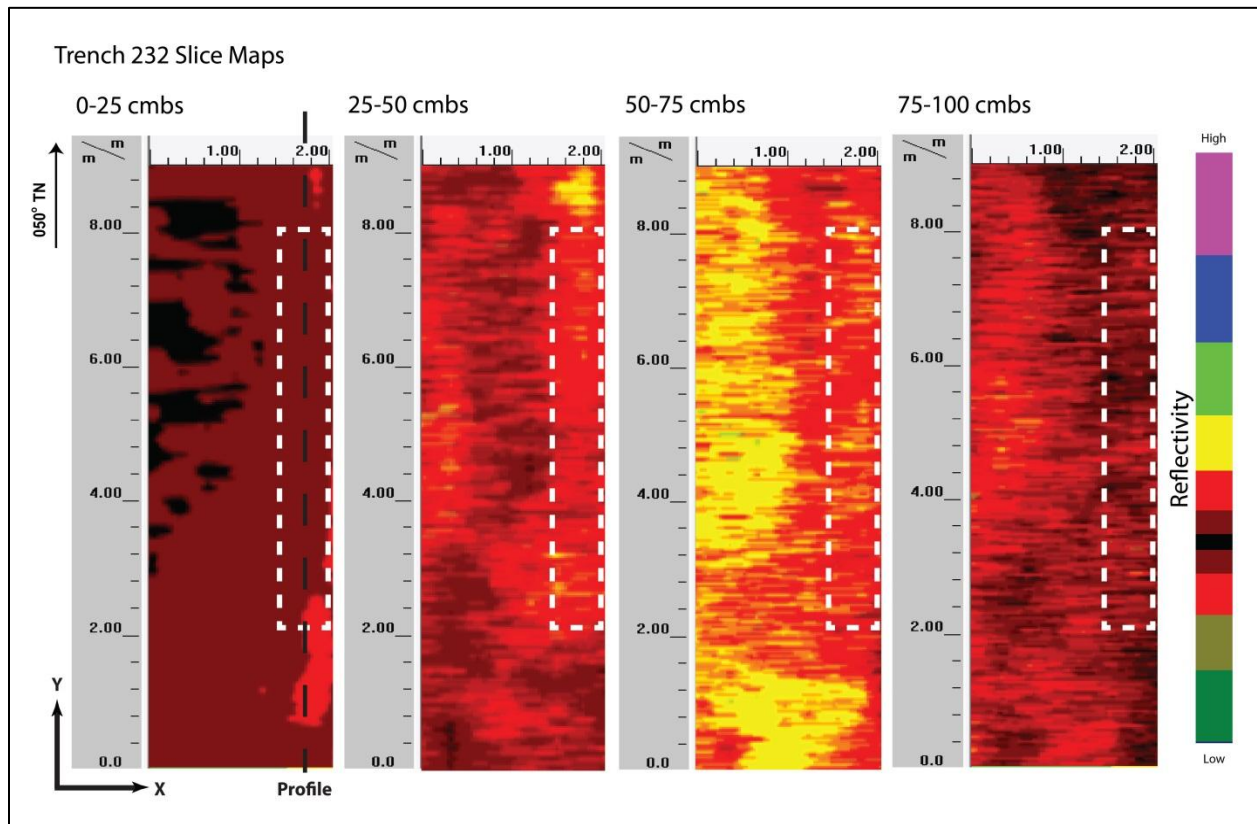


Figure 275. Slice maps of T-232 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 276). Strata Ia to Ic were all clearly observed and occurred near the ground-truthed depths. Strata included: asphalt, extremely gravelly silty sand, very gravelly silty sand fill, extremely gravelly sand, loamy sand fill, sandy clay loam, silty sand, natural sand and natural gravelly sandy clay. A gas line was found 0.4 mbs. The gas line did not show up on the profile or slice maps. This may be due to the fact that the pipe was not comprised of metal or because the diam of the pipe was less than 0.05 m. No other discrete objects or other stratigraphic transitions were observed in the GPR results or subsequent excavation

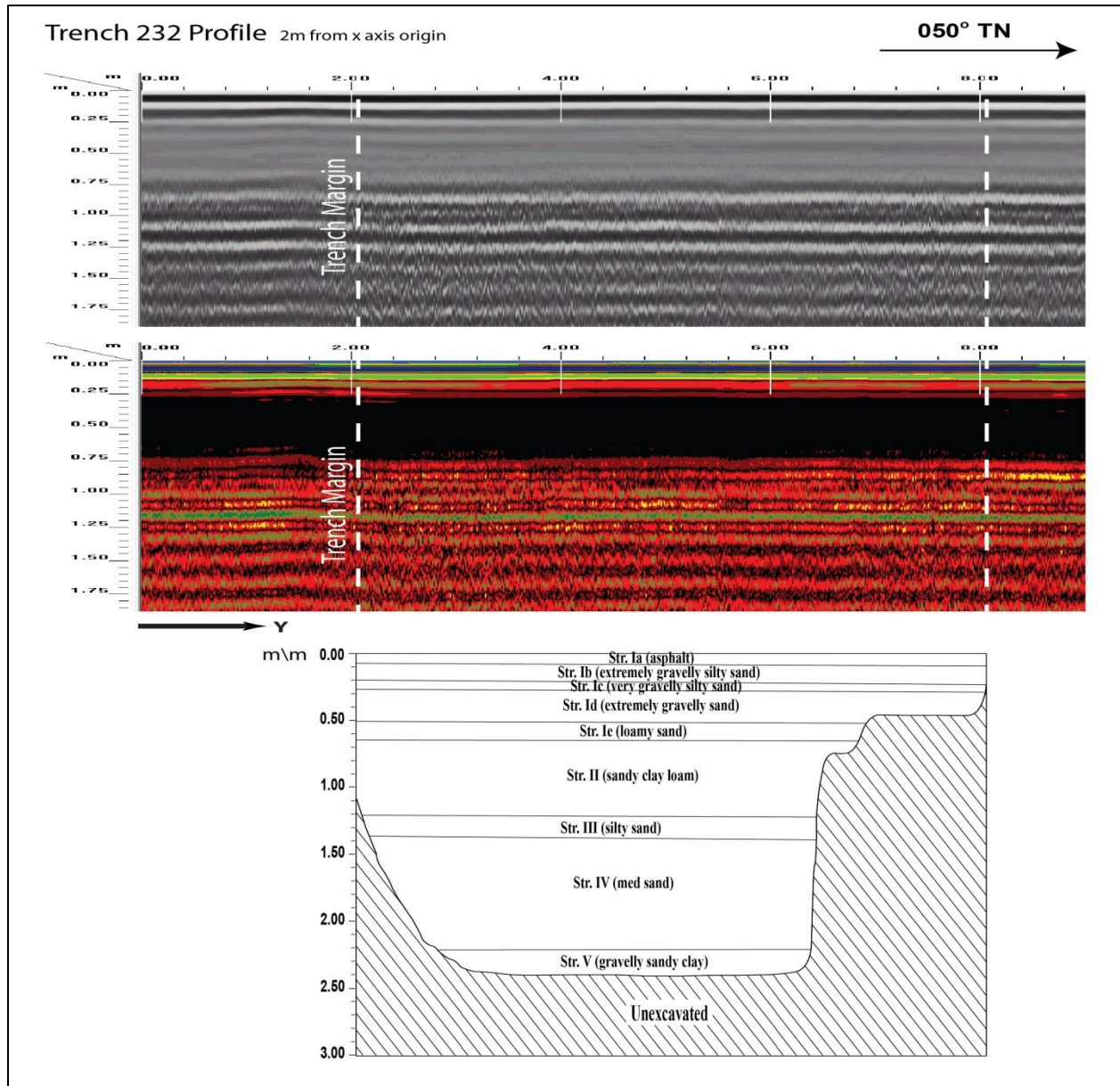


Figure 276. Visual comparison of excavated profile and GPR signal profile of T-232

Test Excavation 232A

T-232A measured 0.6 m by 6.0 m and was oriented northeast to southwest and was located within the road cut of Cooke Street, 19.0 m northeast of Cooke Street and Pohukaina Street intersection. The GPR grid measured 2.0 m by 8.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: sewer line within the excavation footprint as well as 1.4 m northwest, water line 1.6 m southeast. A gas line was encountered 0.4 mbs running the length of the southeast side and a sewer line was encountered 1.02 mbs on the northern corner of the excavation.

A review of amplitude slice maps indicated a linear feature on the southwest side of the excavation but no utility was revealed in this area. Reflectivity was relatively uniform throughout the grid and decreased with depth except for the linear feature. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs (Figure 277).

GPR depth profiles for T-232A identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 278). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity that occurred around 0.2 mbs. An anomaly was observed in the profile but was not encountered and does not corresponded to the utilities that were encountered during excavation. The maximum depth of clean signal return was approximately 0.9 mbs.

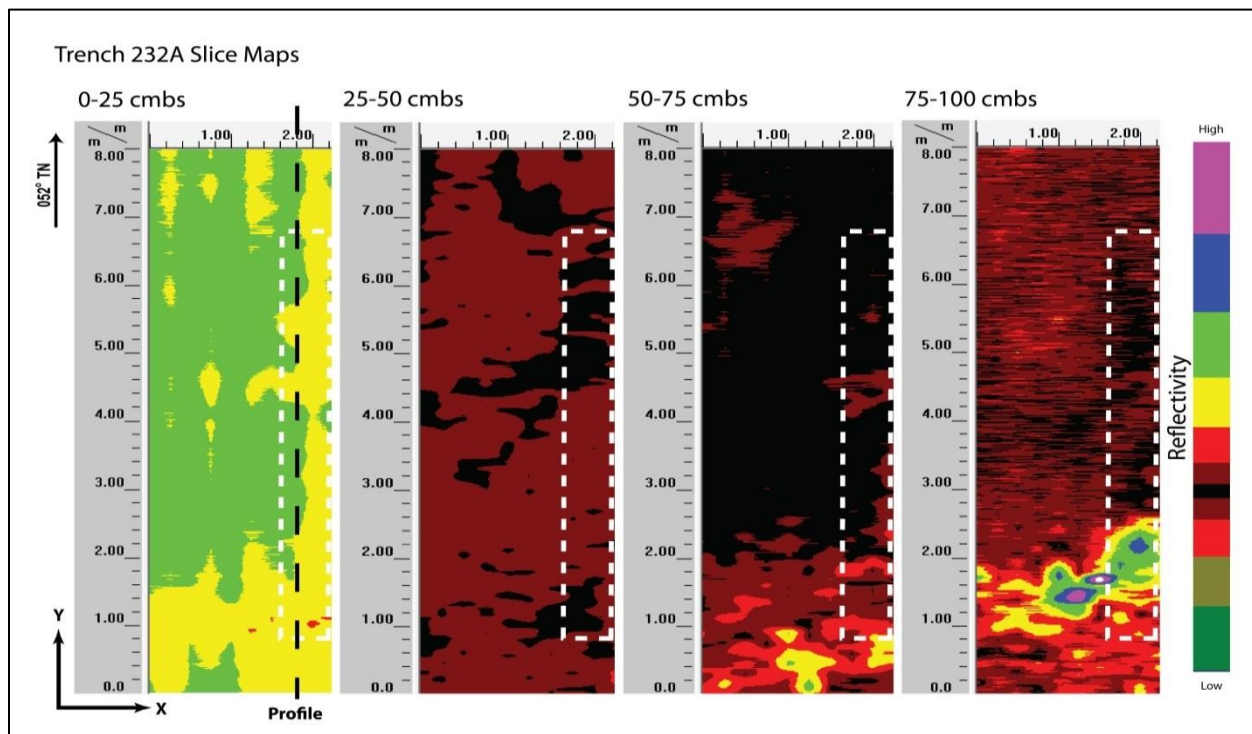


Figure 277. Slice maps of T-232A at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 278). Strata Ia to Ic were all clearly observed and occurred near the ground-truthed depths. A gas line and sewer were found 0.4 and 1.02 mbs, respectively. The gas line and sewer line did not show up on the profile or slice maps. The gas line may not have been observed in the profile because the pipe was not comprised of metal. The sewer line was below the maximum clean signal return depth. No other discrete objects were observed in the GPR results or subsequent excavation.

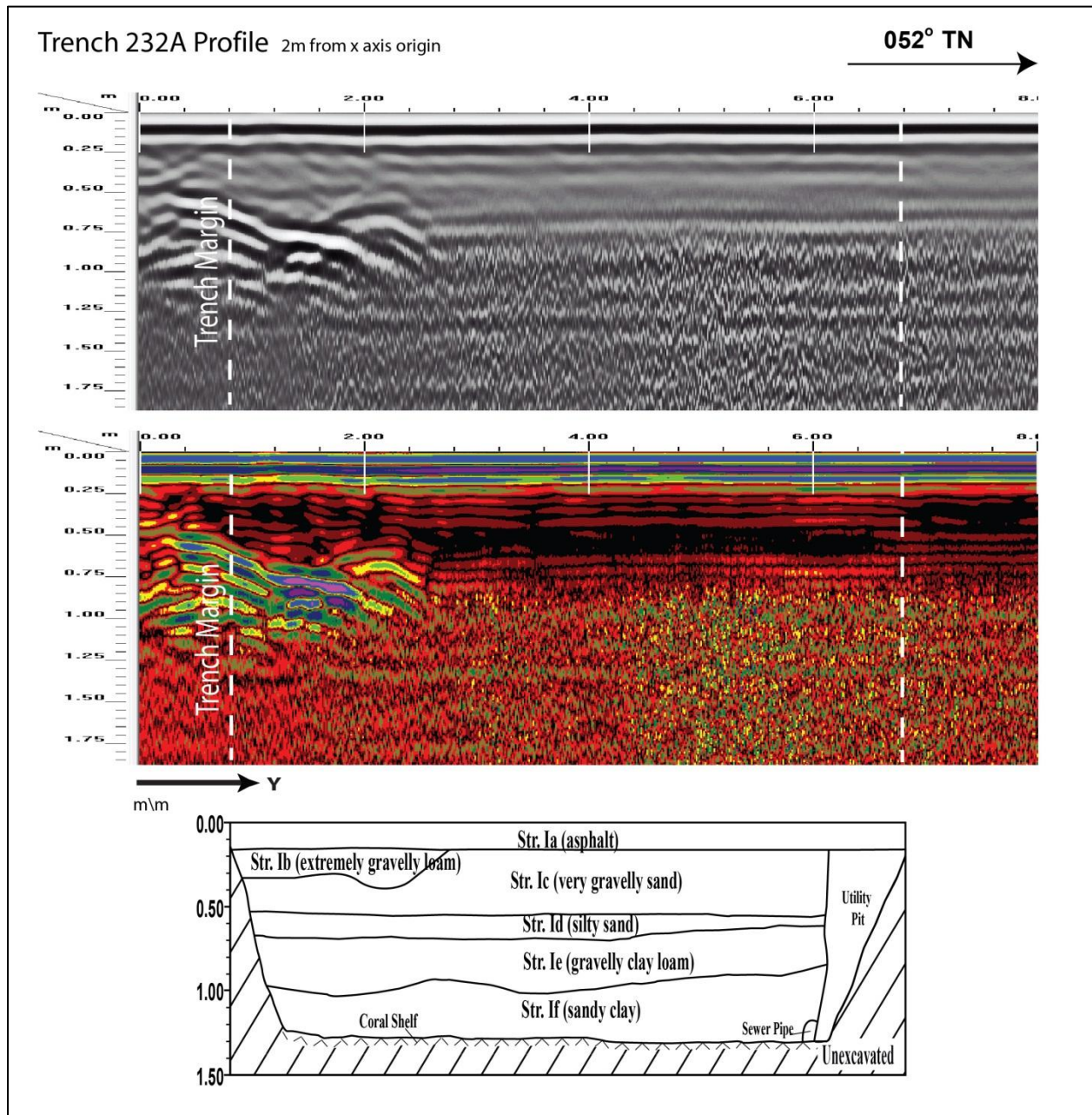


Figure 278. Visual comparison of excavated profile and GPR signal profile of T-232A

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